# THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

# THE INSTITUTION OF

# PRODUCTION ENGINEERS JOURNAL

10 CHESTERFIELD STREET . LONDON . W1 Telephone : GROsvenor 5254/9

*Vol. 37, No. 11* *Price 10/-* *November 1958*


## CONTENTS


"Operational Research in Engineering Production" by N. A. Dudley, Ph.D.(Birmingham), B.Sc.(London), M.I.Prod.E. . . . . 669

"Automatic Equipment for Jobbing Work" by Ian Nickols, A.M.I.Prod.E., J. P. Udal, and O. S. Puckle, M.B.E., M.I.E.E. . 673

Discussion . . . . . 688

"The Application of Spark Erosion Machining" by A. J. Lawrance, G.I.Mech.E., Grad.I.Prod.E. . . . . 694

"The Use of Plastics in Making Jigs, Tools and Moulds" by W. T. John . . . . . 710

International Congress for Production Engineering Research . . 716

Diary Dates . . . . . 693

News of Members . . . . . 719

Hazleton Memorial Library — Additions . . . . . 720



*The Institution of Production Engineers does not accept responsibility for any statements made or opinions expressed in any papers published in the Journal of the Institution.*

Editorial Committee
*B. E. Stokes — Chairman*
*The Rt. Hon. The Earl of Halsbury — President of the Institution*
*H. W. Bowen, O.B.E. — Chairman of Council*
*John Mitford Brice*
*A. A. Francis*
*H. Peter Jost*
*J. C. Z. Martin*
*J. J. Peck*
*R. V. Rider*
*M. J. Sargeaunt*
*R. J. Temple*

Editor
*M. S. C. Bremner*

Secretary of the Institution
*W. F. S. Woodford*

# Grip JIG BUSHES

## — entirely dependable for uniform precision, hardness and quality.

Whatever your requirements in jig bushes you can depend on GRIP to meet your most exacting demands for quality, price and delivery.

The range is complete, covering headless and headed press fit, slip and renewable types, as well as recessed and serrated bushes for plastic and moulded jigs. Catalogues and wall charts gladly sent on request.

TALBOT TOOL CO. LTD.

GRIP WORKS, ROEDALE ROAD, BRIGHTON, SUSSEX. 'Phone: Brighton 55832

# EVEN IF THEY HAVE TO BE SPECIALLY MADE

We've always said that Unbrako screws cost less than trouble.

But it happens that once in a while a customer needs a screw that cannot be found even in the vast Unbrako range.

So we make them to the customer's own specification, or design specially for him.

And even when we have to make specially, Unbrako still costs less than trouble.

So, rest assured, standard or not, you can always safely specify Unbrako screws and make sure of getting the finest fasteners that are made anywhere in the world. Details of sizes and threads will gladly be sent on request.

**UNBRAKO SOCKET SCREW COMPANY LIMITED · COVENTRY**

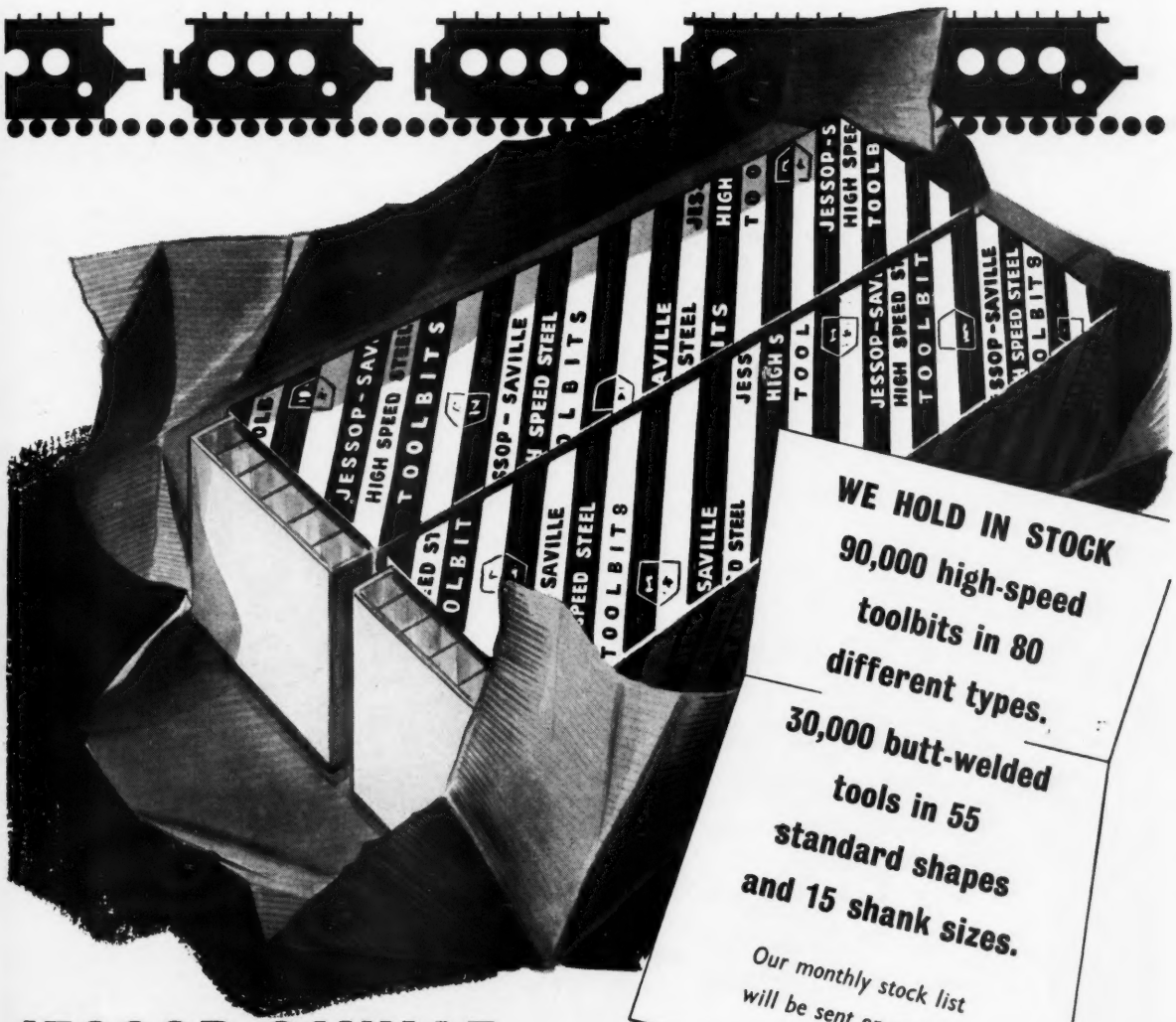
**UNBRAKO SCREWS still COST LESS THAN TROUBLE**

UNBRAKO

# IMMEDIATE DELIVERY

## *of high-speed toolbits & butt-welded tools*

## *KEEPS YOUR PRODUCTION MOVING*




**WE HOLD IN STOCK**
**90,000 high-speed toolbits in 80 different types.**
**30,000 butt-welded tools in 55 standard shapes and 15 shank sizes.**

*Our monthly stock list will be sent on request*

# JESSOP-SAVILLE

***high-speed steel butt-welded tools and toolbits***

WM JESSOP & SONS LTD
BRIGHTSIDE WORKS SHEFFIELD

J J SAVILLE & CO LTD
TRIUMPH WORKS SHEFFIELD

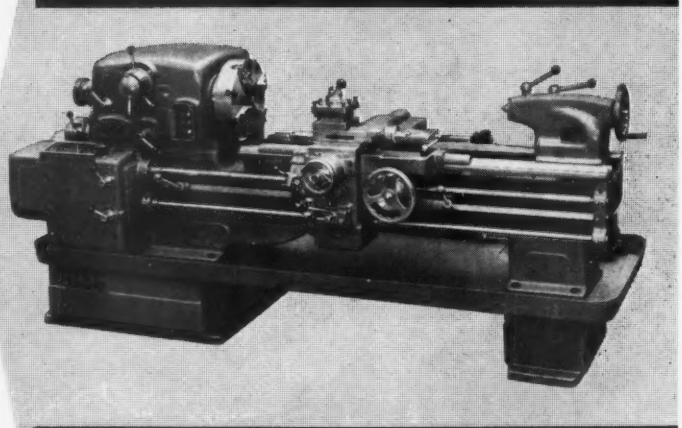
A MEMBER OF THE B.S.A. GROUP

Dean Smith & Grace
KEIGHLEY LIMITED ENGLAND
TELEPHONE: KEIGHLEY 5261 (7 LINES) TELEX No. 51-123

AMERICAN STANDARD CAMLOCK SPINDLE NOSES

...featured on all D.S.G. lathes

- PERMANENT ACCURACY
- INTERCHANGEABILITY
- RIGID MOUNTING
- RAPID CHANGING



...wing ENGINE LATHE

Note the spindle bore size, and oversize Camlock flange on these types:

| | | |
|---|---|---|
| 13" swing | D1-6" | 1⅝" hole |
| 17" swing | D1-8" | 2⅝" hole |
| 21" swing | D1-11" | 3⅝" hole |
| 25" swing | D1-11" | 4⅛" hole |
| 30" swing | D1-11" | 4⅝" hole |

*We manufacture....*

DSG

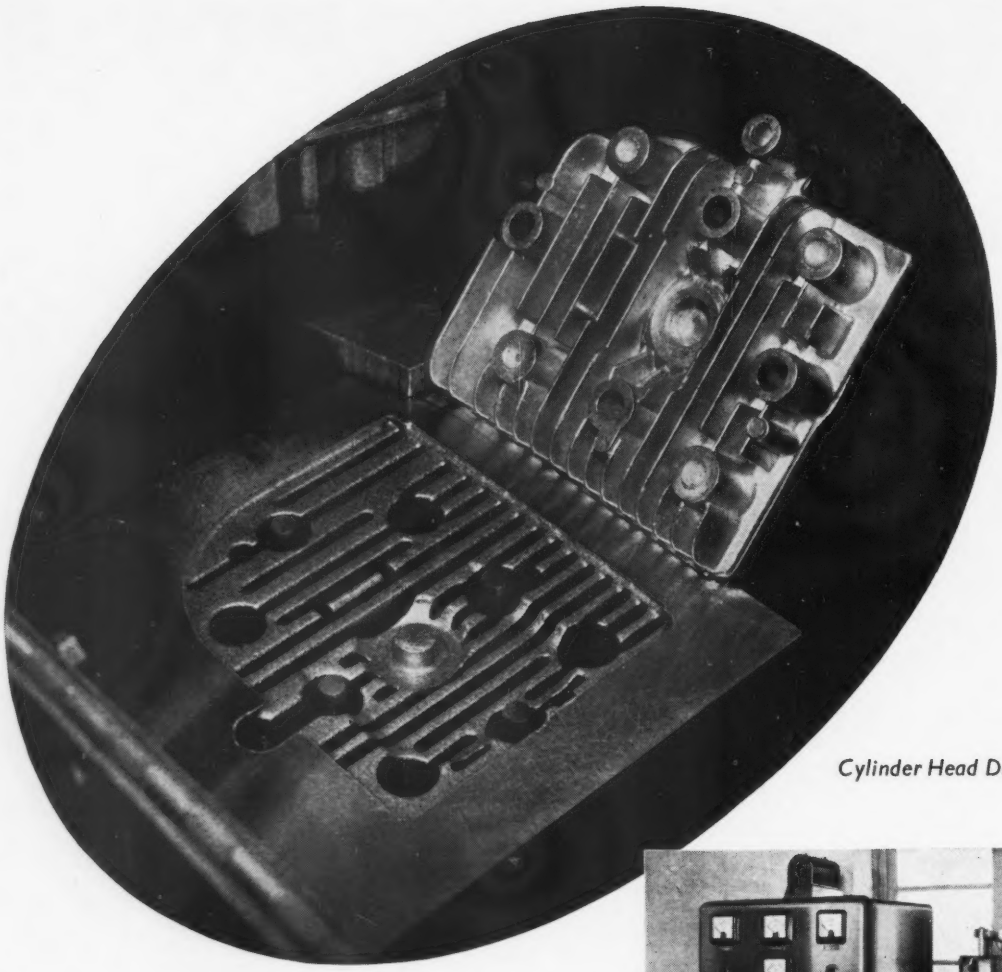
DESCRIPTIVE LITERATURE SENT ON REQUEST

**ABRASIVE BELT MACHINES**

PRODUCT OF THE Morrisflex GROUP OF COMPANIES

HEAD OFFICE

B. O. MORRIS LIMITED, BRITON ROAD, COVENTRY. TEL: 5081



Cylinder Head Die

# SPARK MACHINED from the SOLID

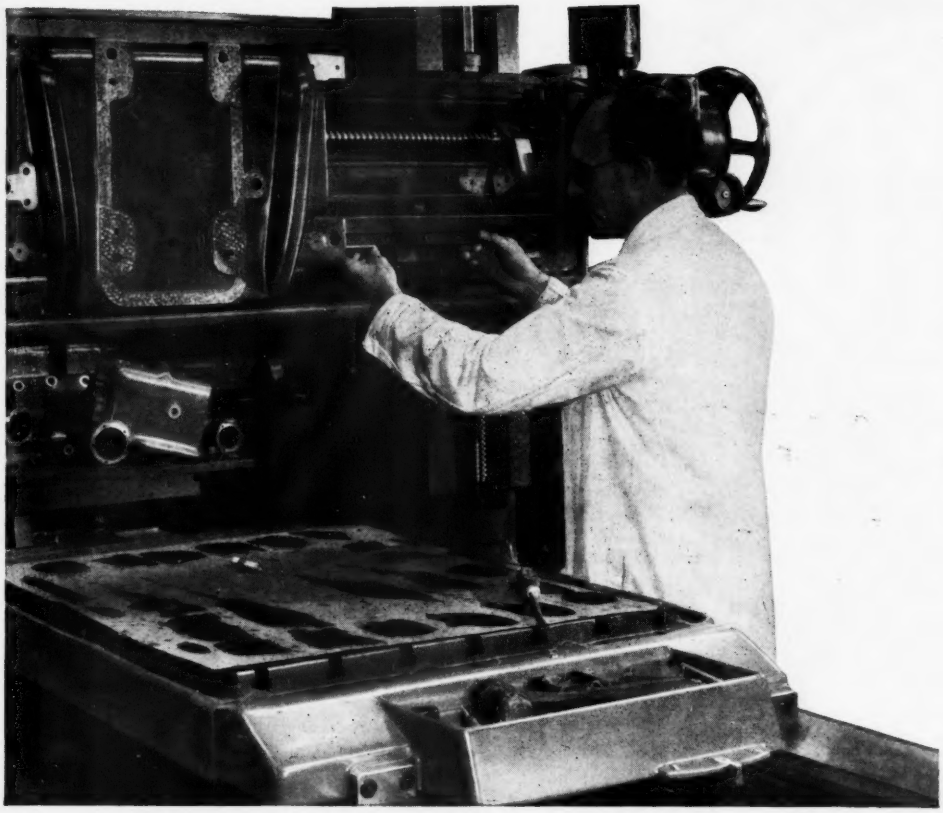
***SPARCATRON MARK III MODEL INCORPORATING THE LATEST IMPROVEMENTS***

**IDP**

**IMPREGNATED DIAMOND PRODUCTS LTD · OF GLOUCESTER · ENGLAND**

Sole Agents for the United Kingdom

BURTON GRIFFITHS & CO LTD · KITTS GREEN · BIRMINGHAM 33



# craftsmanship counts...

High precision machine tools repay care taken in the rebuilding and renewal of parts which have become worn. The jig boring and milling machines manufactured by the Société Genevoise are serviced and renewed by the highly-skilled craftsmen of Sogenique (Service) Ltd. The illustration shows Mr. H. Bond of the Assembly Department assembling the gib-strip on the spindle carriage of the Hydroptic-B jig-boring machine, an operation requiring meticulous care in order to achieve perfect control of the settings of the spindle carriage. It is with such care and craftsmanship that the repair of Société Genevoise machine tools is carried out. Sogenique (Service) Ltd. also install and maintain these machine tools as well as train personnel in their operation.

**Sogenique (Service) Ltd.**

NEWPORT PAGNELL BUCKS. TELEPHONE NEWPORT PAGNELL 460/1/2

BTG

# standard side and face cutters FROM STOCK

The Birmingham Tool and Gauge Company now offer standard Side and Face Cutters from stock. This stock ranges from 2½" to 8" diameter in the most frequently used widths; a bore size of 1¼" is adopted for all cutters 5" diameter and over. The entire range conforms to B.S.I. specification together with High Power tooth form and are immediately available.

Despatch is guaranteed by return.

Write for Stock Card or Leaflet showing precise sizes immediately available to you.

**BIRMINGHAM TOOL & GAUGE CO. LTD**

SOHO HILL, BIRMINGHAM 19

Telephone: NORTHERN 3344 Telegrams: RELIEF BIRMINGHAM 19

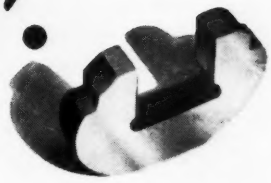
LONDON OFFICE: 26 HOLBORN VIADUCT, LONDON, E.C.1

Telephone: FLEET STREET 6454 Telegrams: BIRMTOOL, CENT, LONDON

Beardmore

# 40 magnets per min!

*Ground on two faces simultaneously*



*15 times quicker than single sided surface grinding*

. . . .

ROWLAND Duplex Surface Grinders are now in successful operation in the works of most leading makers of permanent magnets. Reports tell of exceptional results, of which the production figures quoted above are typical.

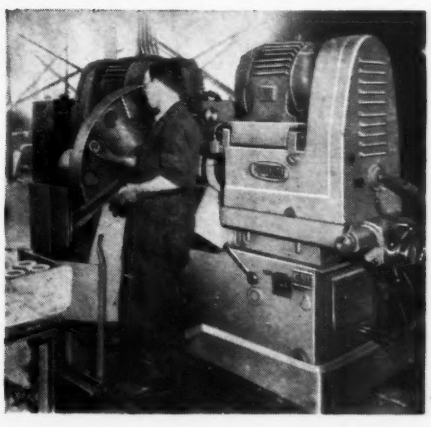
ROWLAND

## DUPLEX SURFACE GRINDERS

THE METHOD IS APPLICABLE TO FERROUS AND NON-FERROUS COMPONENTS, CERAMICS, BONDED ASBESTOS PRODUCTS, ETC., AND RESULTS IN PRODUCTION INCREASES UP TO 100% AND MORE.

***Check the jobs in your own works where ROWLAND DUPLEX SURFACE GRINDERS would slash production costs.***

OUR TECHNICAL REPRESENTATIVES ARE READY, ABLE AND WILLING TO CO-OPERATE WITH YOU.



F.E.ROWLAND & CO.LTD.

Telephone: HEATON MOOR 3201-2-3

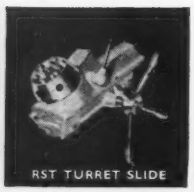
Telegrams: HEROIC, REDDISH

REDDISH · STOCKPORT · ENGLAND

*SOLE EXPORT AGENTS*: DRUMMOND ASQUITH (SALES) LTD., Halifax House, Strand, London, W.C.2. Tel.: TRAfalgar 7224.

PRH 1 HEADSTOCK

CSP COMPOUND SLIDE


RST TURRET SLIDE

TSC TAILSTOCK

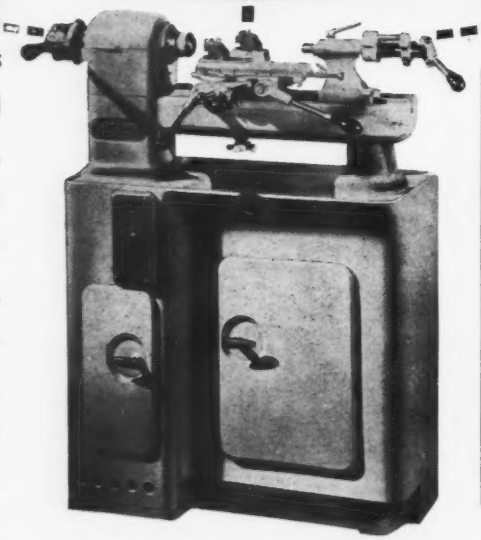
LPH HEADSTOCK

CWP CUT-OFF SLIDE

LRST TURRET SLIDE

TUC TAILSTOCK

Machine shown is fitted with . . . Model P.R.H. Headstock, C.T.P. Lever-operated compound slide and T.T.C. Tailstock. A wide range of accessories is available. Send for illustrated data from stockists.



**DISTRIBUTORS**

**Buck & Hickman Ltd.**
**Otterspool Way, Watford By-Pass**
**Watford, Herts**

•

**Burton, Griffiths & Co. Ltd.**
**Mackadown Lane, Marston Green,**
**Birmingham**

•

**Modern Machine Tools Ltd.**
**Gosford Street,**
**Coventry**

•

**E. H. Jones (Machine Tools) Ltd.**
**Garantools House, Hove,**
**Sussex**

•

**C. H. Joyce Ltd.**
**40 Monkton Street,**
**Kennington, London, S.E.11**

•

**Rockwell Machine Tool Co. Ltd.**
**Welsh Harp, Edgware Road,**
**London, N.W.2**

•

**Stedall Machine Tool Co.**
**145/157 St. John Street,**
**Clerkenwell, London, E.C.1**

# 16 STANDARD BENCH AND CABINET MODELS!

**SMART & BROWN**
**Series L**
Many spindle speeds and combinations available with standard attachments.

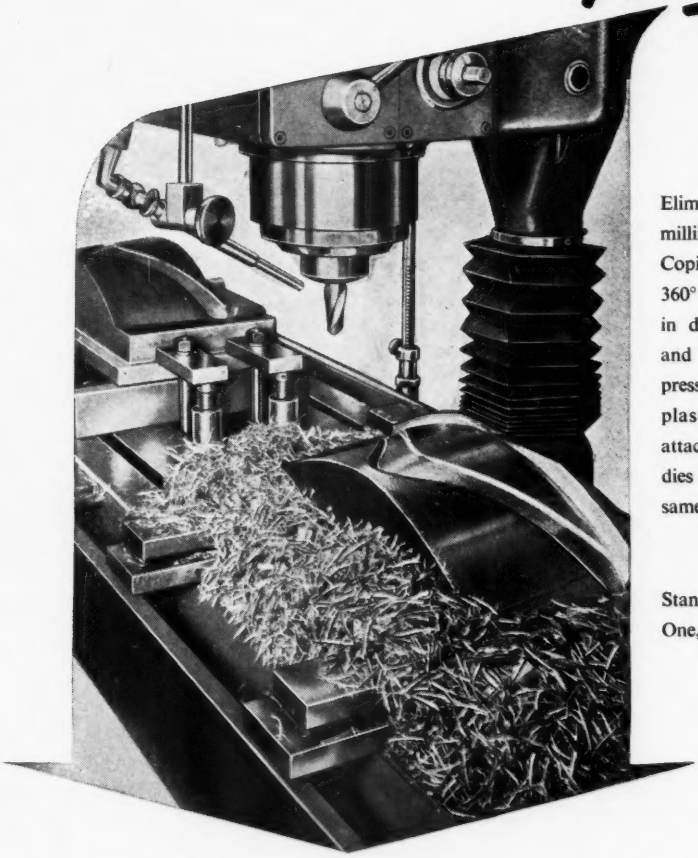
**EARLY DELIVERIES**

**S&B**

**SMART & BROWN (MACHINE TOOLS) LTD.**
**25, MANCHESTER SQUARE, LONDON, W.I.**
Telephone: **WELBECK 7941 (PBX)** Cables: **SMARTOOL, WESDO, LONDON**

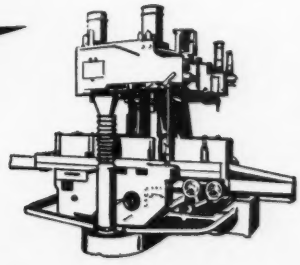
NRP

# Make your Die Sinking *Automatic*



Eliminate the human element by copy milling and die sinking the 'Rigid' way. Copies vertical angles up to 90° and 360° profiles with any number of changes in direction without circular table and with constant feed. Light feeler pressure permits the use of wood or plaster for masters. Reverse image attachment enables top and bottom dies of either hand to be made from the same master.

Standard table sizes up to 92½" x 25⅝" One, two, four or six spindles.



— By INSTALLING

SWISS **RIGID**

***AUTOMATIC* HYDROCOPYING MACHINES**

*Send for the illustrated brochure to Sole U.K. Distributors*

**DOWDING & DOLL LTD**

346 KENSINGTON HIGH STREET, LONDON, W.14

Telephone WESTERN 8077 (8 lines) Telegrams ACCURATOOL HAMMER LONDON

141

# NOW IT'S NORTON ABRASIVES FOR *ALL* CUTTING-OFF JOBS

## B9 for DRY

For high production dry cutting jobs on steels of all types use Norton B9 Resinoid Bonded Wheels. Their fast clean cutting abilities are enhanced by the added roughness of the sides—achieved by allowing the outside layers of abrasive grain to protrude naturally from the sides of the wheel giving more clearance in the cut. These are designated 'F' Sides. So, for the most economical dry cutting-off jobs with a really good finish specify Norton B9 Wheels with 'F' Sides.

## R50 for WET

These new Norton Rubber Bonded Wheels have been developed for wet cutting operations. Extraordinary results have already been achieved on high-speed, alloy and other heat sensitive steels. Consider the possibilities of wet cutting with Norton R50 wheels if your jobs are being marred by excessive burring or burning.

Both these Norton Wheels are outstanding for their speed and quality of cut and for their long, economical performance. For the best advice on dry cutting with B9 Wheels or wet cutting with R50 wheels, consult your Norton or Alfred Herbert representative—or write to us

**NORTON GRINDING WHEEL CO. LTD.** NORTON ABRASIVES

**WELWYN GARDEN CITY, HERTS.** **Telephone: WELWYN GARDEN 4501 (10 lines)**

*Enquiries also to* **ALFRED HERBERT LTD., COVENTRY**

NORTON and BEHR-MANNING *factories also in Argentina, Australia, Brazil, Canada, France, Germany, Italy, Northern Ireland, South Africa and U.S.A.*

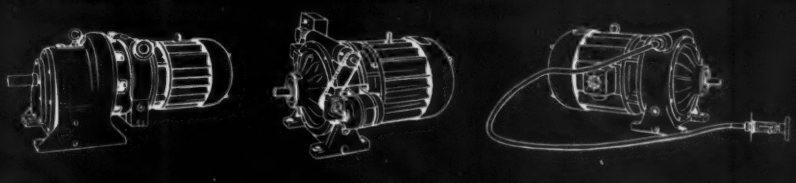
NGW/B9R50/141

- Stepless speed variation over a 9 to 1 output speed range (1/3 to 3 times the input speed).
- Constant horse-power transmitted throughout the speed range.
- Flange mounted motors (when required) giving output speeds from 320 to 2880 r.p.m. and from 480 to 4320 r.p.m.
- Output speeds as low as 3 to 27 r.p.m. can be obtained with flange mounted Reduction Gears. Special units are available for even lower output speeds.
- Exceptionally light, sensitive and accurate control of speed setting.
- Co-axial input and output shafts which rotate in the same direction.
- Service reliability resulting from a simple design manufactured to high precision limits.
- Compactness, with consequent ease of mounting as an integral part of a machine.
- Vibrationless and silent performance.
- Standard range 1/33 h.p. to 15 h.p.

*Illustrated is a 1½ h.p. variator*

# A GEARLESS GEARBOX ...

# Kopp



***PLEASE ASK FOR ONE OF OUR DEMONSTRATION VANS TO CALL AT YOUR WORKS***

# PNEUTOMATION

## *perfect control for complex jobs*

Before production problems become major headaches, get a vest-pocket elephant into your works—PNEUTOMATION! PNEUTOMATION gives you jumbo-sized performance—plus docility. It never varies, never tires, delivers exactly the right amount of power, in the right place at the right time—every time. With PNEUTOMATION in control, human errors and operator fatigue become things of the past, production speeds up, costs and rejects drop. Simple design, careful workmanship and completely non-corrodible materials cut replacement and maintenance costs, make Lang PNEUTOMATION a really long-lasting, trouble-free pneumatic power system.

***Pneutomation***
***never forgets***
***to operate***

**PNEUTOMATION**
**energy under control**

**The 'Pneulang' basic cylinder unit, just one of the 264 cylinders available 'off-the-shelf'. The range of PNEUTOMATION equipment also includes many types of manual and automatic valves, lubricators, airflow regulators, pipes and fittings, etc.**

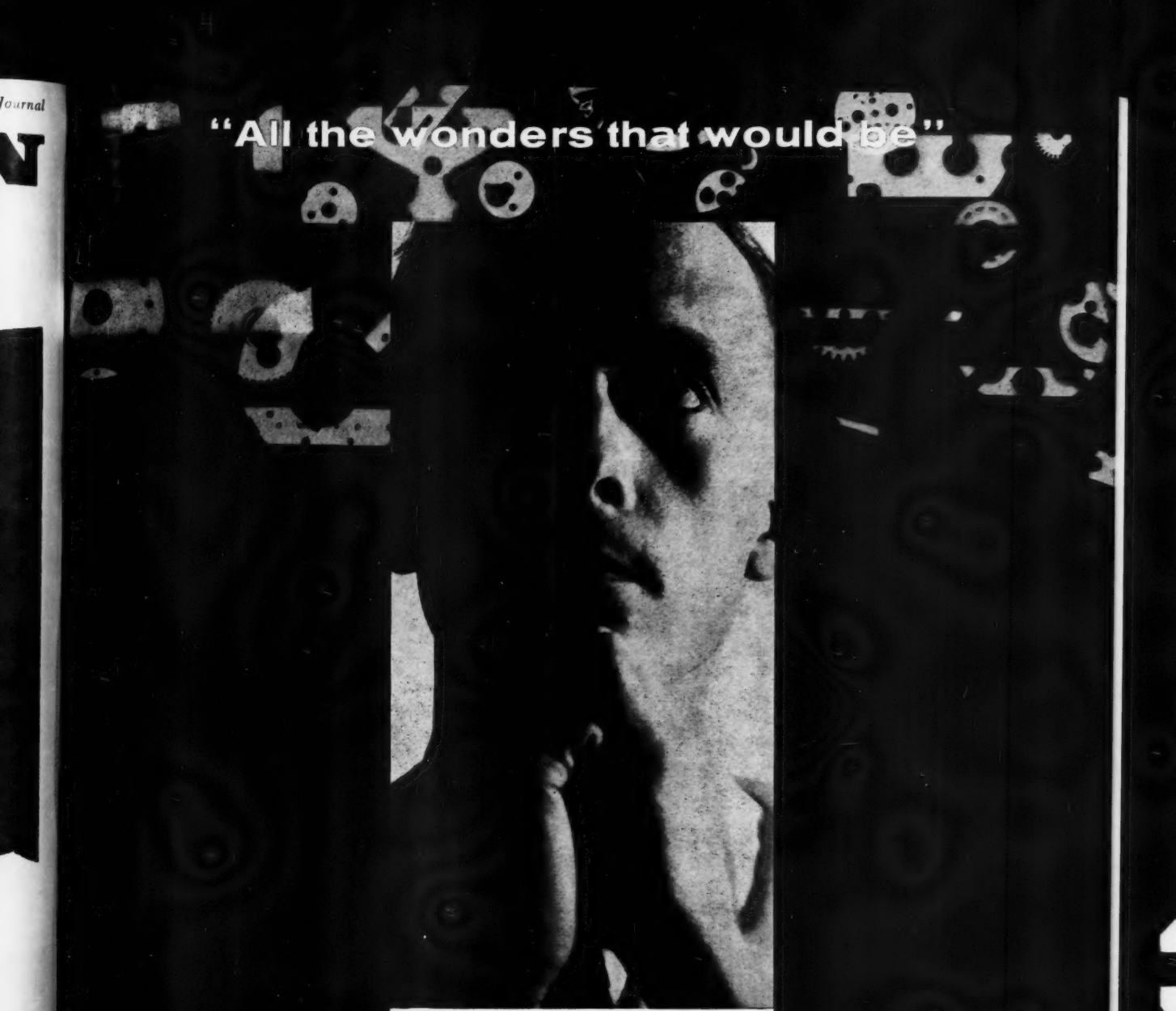
*Plan with*

**LANG PNEUMATIC LTD**

VICTORY WORKS BIRMINGHAM ROAD WOLVERHAMPTON Tel: 25221-2-3

P.1.5C

Associated with Desoutter Brothers (Holdings) Ltd.




**Insulator Division**
Electro-ceramic insulators, mass-produced to close dimensional tolerances, for radio, telecommunication and electronic apparatus, cooking, heating and pyrometric equipment.

**Electric Heating Division**
'Chromalox' ceramic-embedded strip, ring, pad and cartridge electric heating elements and 'Tubalox' sheathed wire elements for domestic and industrial purposes. Also complete appliances including air and immersion heaters.

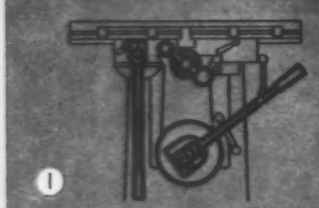
**Gas Burner Division**
Non-corrosive ceramic tipped gas jets and gas burners for domestic and industrial heating and lighting together with a comprehensive range of spray jets for chemicals, oils and other fluids.

In the forward march of industry, progress starts with visionaries' dreams... with dreams awaiting translation into practical possibilities. And that's where Geo. Bray have a part to play. In close on a century, the Company has made many dreams come true, turning the ideas of others and of themselves —for Geo. Bray engineers are visionaries too—into solid realities.
For lighting and heating, for electrical insulation, for precision engineering, there is hardly an industry that does not rely on the products of this 95-year-old Company. Today, forward-looking people are constantly coming to the Insulator, Electric Heating and Gas Burner Divisions of Geo. Bray for advice on the development of new ideas in these all-embracing fields.

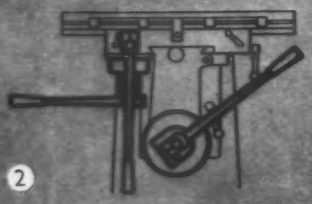
**GEO. BRAY**
**and company limited**
**GAS JETS AND BURNERS**
**ELECTRIC HEATING ELEMENTS**
**ELECTRO-CERAMIC INSULATORS**
Leicester Place, Leeds, 2
Leeds 20981 (9 lines)
London Office:
305 Grand Buildings,
Trafalgar Square, W.C.2

# 6 × 4 = 24

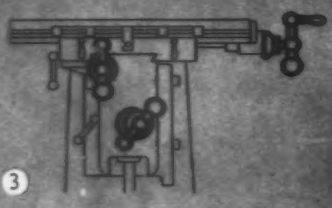
TYPES OF FEED | SPEED RANGES | POSSIBLE COMBINATIONS



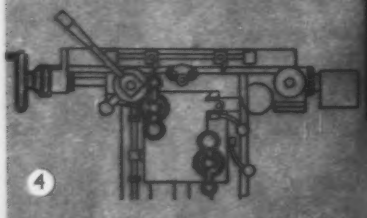
1 Hand Feed—lever, screw, lever.



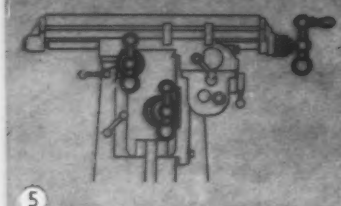
2 Hand Feed—lever, lever, lever.



3 Hand Feed—Screw, screw, screw.



4 Multiform—semi-automatic cycle.

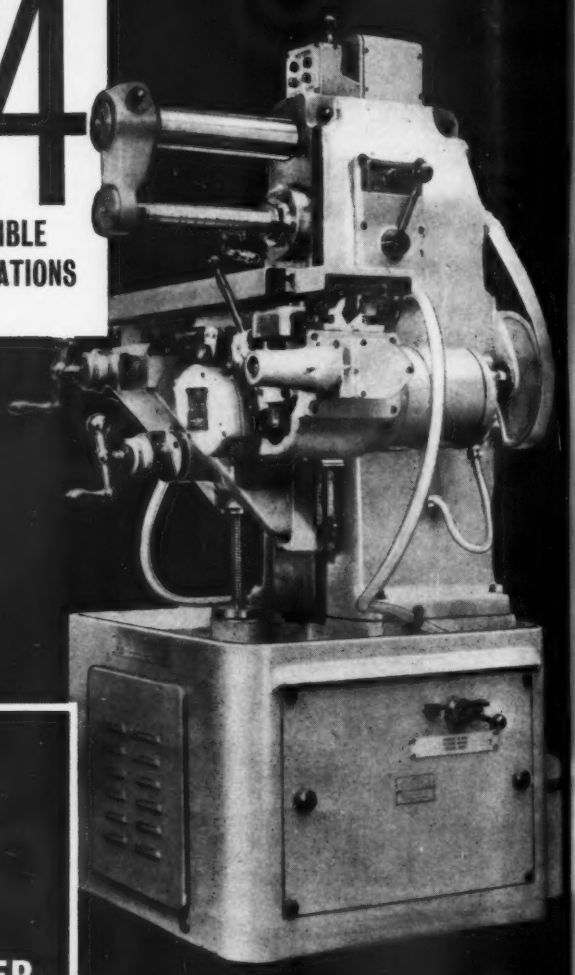


5 Normal automatic feed.

that's the beauty of the

# A&S

## MODEL 'I' HORIZONTAL MILLER



6 With automatic cycle.

***WHY PAY FOR 'SPECIAL' FEATURES YOU MAY NEVER USE?***

When you equip with A & S Model 'I' Millers you choose from 4 ranges of speeds and 6 different feed arrangements the best combination* for a particular job. Both hand-feed and automatic types can however be supplied with special attachments for special operations. No other small milling machine offers similar versatility or higher production capacity for so wide a range of work.

**TABLE** 26″ × 7″
**LONGITUDINAL TRAVERSE** = 10″
**VERTICAL TRAVERSE** = 10″
**TRANSVERSE TRAVERSE** = 5½″-6″

**With the A & S Model 'I' brochure in front of you, you would know exactly what we mean.*

*Built up to a standard-not down to a price*

*Write for illustrated leaflet*

# ADCOCK & SHIPLEY LTD

P.O. Box 22, Ash Street, Leicester. Telephone Leicester 24154-6. Telegrams & Cables: Adcock, Leicester.

# *Current Practice*

Araldite epoxy resins provide the answer to many problems encountered in the manufacture of electrical equipment. Bushings are a good example. Made with Araldite, they exploit the outstanding properties of the epoxies—remarkable void-free adhesion to metal, outstanding anti-tracking qualities, high mechanical strength, low shrinkage, stability, resistance to climatic conditions and chemicals and excellent dielectric properties. The components shown are cast bushings for use in air, oil or compound on potentials up to 11,000 V, and are manufactured by J. R. Ferguson (Electrical Engineers) Limited, Dukinfield, Cheshire.

*Araldite epoxy resins are used*

- ★ for bonding metals, porcelain, glass, etc.
- ★ for casting high grade solid electrical insulation
- ★ for impregnating, potting or sealing electrical windings and components
- ★ for producing glass fibre laminates
- ★ for producing patterns, models, jigs and tools
- ★ as fillers for sheet metal work
- ★ as protective coatings for metals, wood and ceramic surfaces

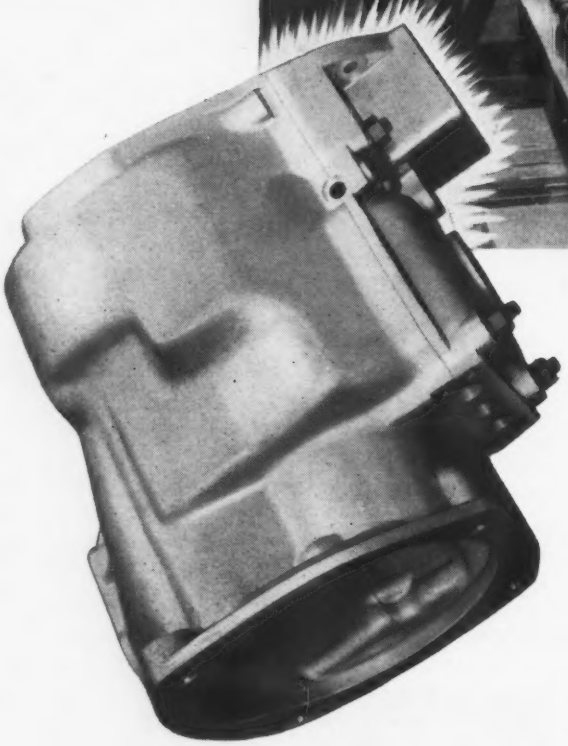
# Araldite *epoxy resins*

*Araldite is a registered trade name*

CIBA (A.R.L.) LIMITED Duxford, Cambridge. Telephone: Sawston 2121

*AP317*

# *Fine Boring*
## *The* PRECIMAX *Way*



★

**THREE-POSITION AUTOMATIC HYDRAULIC CROSS SLIDE SOLVES PROBLEM OF BORING CLOSELY SPACED HOLES AT ROVER CO. LTD.**

The problem of fine boring close centre holes in this Rover gearbox is ingeniously overcome by use of the PRECIMAX three position hydraulically operated cross slide. The necessary transverse movements are preselected and linked with the longitudinal feed motions in a fully automatic cycle.
The three bores (two at 0.625 in. dia. and one at 0.6875 in. dia.) are repeated by two spindles at the opposite end and in addition to close limits on diameter and relative position, this multiple operation fulfils exacting demands in the accurate alignment of the opposing bores. The six holes are bored using solid tungsten carbide shank boring bars in a floor-to-floor time of 2.85 minutes.

*Send for full details of PRECIMAX Fine Boring Machines to . . .*

**LANDIS LUND LIMITED, CROSS HILLS, KEIGHLEY.** **'Phone: Cross Hills 3211**

# Grinds Spiral Cutters and Clearance Angles by DIRECT SETTING

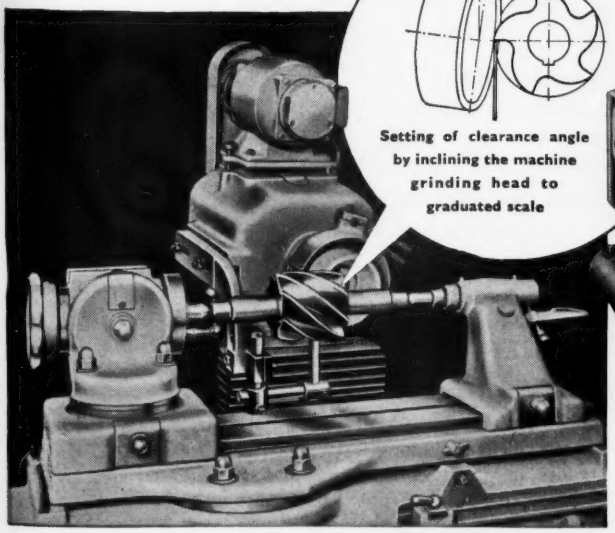
## SCHÜTTE
### TOOL and CUTTER GRINDING MACHINE

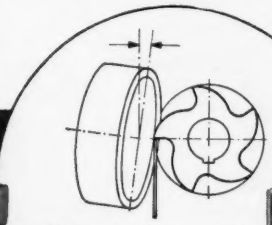
**Head Swivels and TILTS**

**Grinding Spindle runs in Ball Bearings**

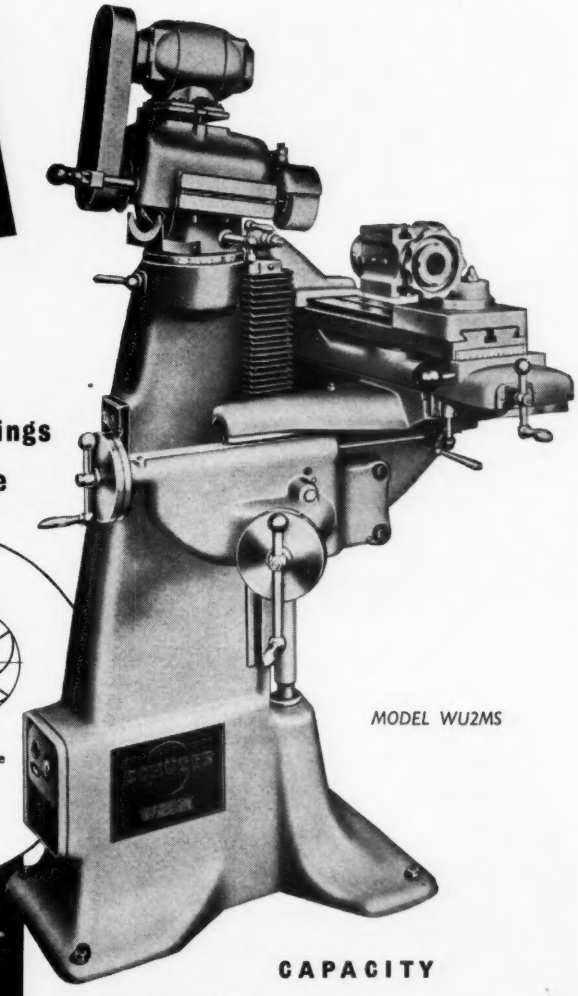
**Precision Ball Bearing Track Table**

**Sensitive Table Movement**





Setting of clearance angle by inclining the machine grinding head to graduated scale



MODEL WU2MS

**CAPACITY**

| | |
|---|---|
| Centre height ... ... ... ... | 4½" |
| Grinding diameter ... ... ... | Max. 10" |
| Centre distance=grinding length ... ... | 12½" |
| Helix angle adjustment (right and left hand) ... ... | 60°-0°-60° |
| Clearance angle inclinability ... | 12°-0°-12° |
| 2 Grinding Spindle Speeds | appr. RPM 3000/6000 |

*Write for detailed literature to:—*

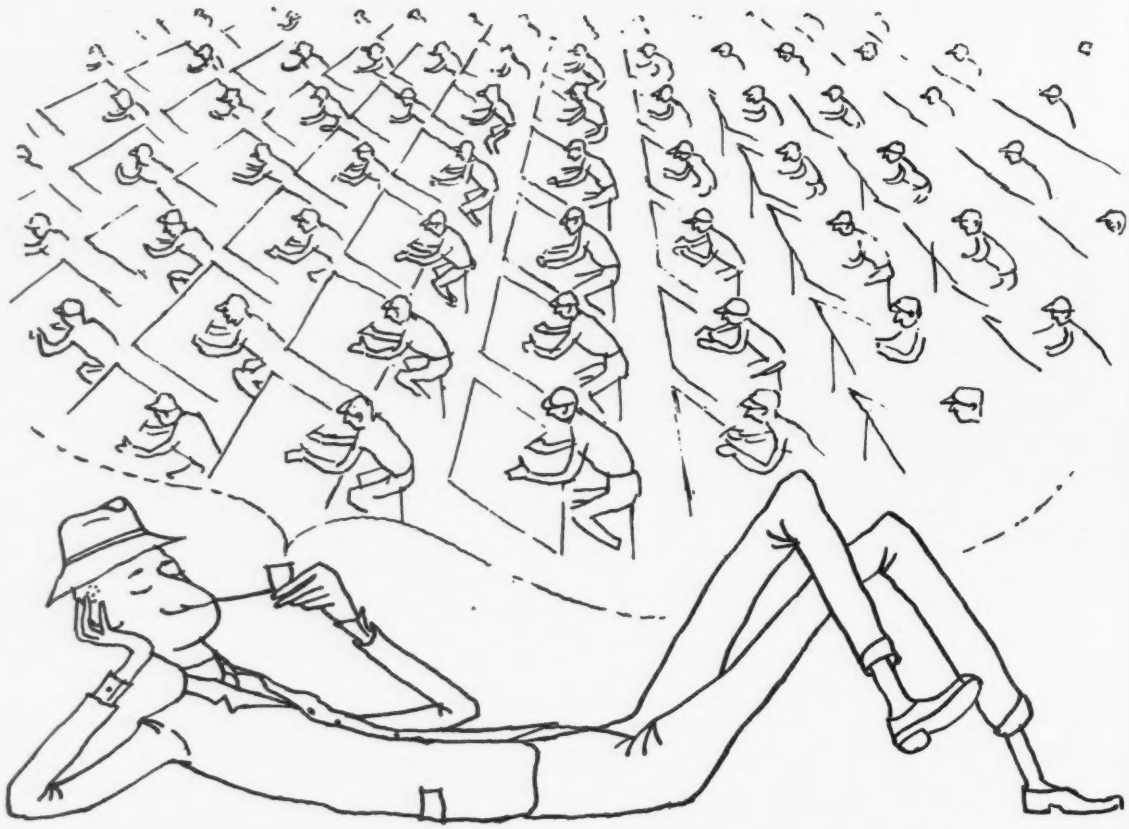
**ROCKWELL**
MACHINE TOOL CO. LTD.

WELSH HARP, EDGWARE ROAD, LONDON, N.W.2. TELEPHONE: GLADSTONE 0033

ALSO AT • BIRMINGHAM—TELEPHONE SPRINGFIELD 1134/5 • STOCKPORT—TELEPHONE STOCKPORT 5241 • GLASGOW—TELEPHONE MERRYLEE 2822

SCH5

# Pipe Dream ?



When you're dreaming up plans to increase production it's time to wake up to AZOFLEX. It's the *only* process to apply a controlled quantity of developer, thus ensuring optimum quality at all running speeds—and it's the only daylight reflex copying process. There are no dangerous chemicals and because no ducting is necessary to take away offensive fumes, machines are freely movable from place to place. Exposing, developing and print delivery are completely synchronised and output is virtually as fast as the operator. In plain language the AZOFLEX MODEL 221 can produce more than one hundred 20″×30″ prints an hour at a lower cost per print than you ever dreamed.

***AZOFLEX MODEL 221***

Synchronised printing and developing machine. Capacity: cut sheets and rolls up to 42 in. wide. Printing speed: from 6 in. to 15½ ft. per minute. Dimensions: Height 50 in., width 71 in., depth 52 in. with delivery tray extended. Weight: approximately 850 lb.

**ILFORD** *Azoflex*

Enquiries to: Ilford Limited,
Industrial Sales Dept. AZ13AA.
Ilford, Essex
Telephone: Ilford 3000

*MACHINES AND MATERIALS FOR DRAWING OFFICE PHOTOPRINTING*

# MILLS grooved pins

NO REAMING

NO TAPPING

DRILL AND DRIVE HOME!

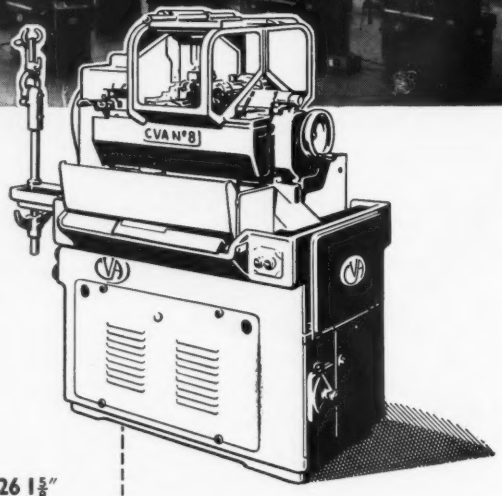
12 different types to suit all needs

EXORS. OF JAMES MILLS LTD.

BREDBURY STEEL WORKS
WOODLEY. NR. STOCKPORT
Telephone: WOODLEY 2231.(10 lines) Telegrams: "MILLS" PHONE WOODLEY

# Monarch

## *turns on CVA Automatics*




More and more radio manufacturers are fitting B.S.R. MONARCH record changers, known for their unerring precision. To meet the resultant production demand, Birmingham Sound Reproducers Ltd., sought the best in automatic turning equipment and after extensive study their choice was CVA.

This battery of 32 No. 8 automatics was tooled and installed at the largest auto changer factory in Europe by CVA engineers.

*Capacities available:—*

**No. 8 $\frac{1}{2}$″ – No. 12 $\frac{3}{4}$″ – No. 20 $1\frac{1}{4}$″ – No. 26 $1\frac{5}{8}$″**

**SINGLE SPINDLE AUTOMATIC SCREW MACHINES**

**E. H. JONES (MACHINE TOOLS) LIMITED**

GARANTOOLS HOUSE · PORTLAND ROAD · HOVE · SUSSEX

Telephone: HOVE 47253 Telegrams: Garantools, Portslade

LONDON · BIRMINGHAM · GLASGOW · MANCHESTER · BRISTOL

NRP 2149

# prophecy in metal

## magnesium will make more of lightness

MEL can shape your future in magnesium.
Unrivalled in their knowledge, they
can improve fabrications, simplify production,
raise efficiency and lower costs
wherever lightness with great strength
is essential.

**make more of magnesium**

MAGNESIUM ELEKTRON LIMITED CLIFTON JUNCTION MANCHESTER

London Office: 5 Charles II Street St. James's SW1

*Magnesium Elektron, Inc., New York 20, USA*

MEL

*Prophecy* — a sculpture in magnesium
for MEL by Winston Clarke

# gearb

## CROFTS MAKE THI
## CROFTS (ENGINEERS) LIMITE

### CROFTS SHAFT MOUNTED GEAR UNI

***Fractional to 120 h.p., output speeds from 8 to 425 r.p.m.***

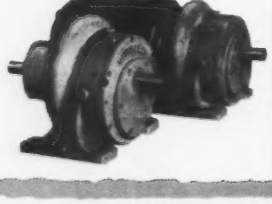
Publication 157

- mount direct on the driven shaft.
- no flexible couplings slide rails or alignment problems.
- ideal for horizontal, or inclined shafts.
- available with platform-mounted motor also variable speed drive.

**POPULAR SIZES AVAILABLE FROM STOCK**

Publications 5329 and 5737

Ritespeed Geared Motors



Publication 521

Radiation Worm Reduction Gears

Publication 358

Multispeed 2, 3 and 4-speed Geared Motors

**CROFTS (ENGINEERS) LIMITED**

**POWER TRANSMISSION ENGINEERS**

**Head Office: Thornbury Bradford 3 Yorkshire**

*Telephone: 65251 (20 lines) Telegrams: "Crofters Bradford Telex" Telex 51186*

**Branches at**

Belfast Birmingham Bristol Cardiff Dublin Glas
Ipswich Leeds Liverpool London Manchester New
Northampton Nottingham Sheffield Stoke-on-T

**REPRESENTATION THROUGHOUT THE WOR**

# oxes

## THINEST YOU CAN BUY
## TE OWER TRANSMISSION ENGINEERS

### UNI OFTS UNIVERSAL MOUNTING WORM REDUCTION GEARS

***Fractional to 6 h.p., ratios up to 60:1***

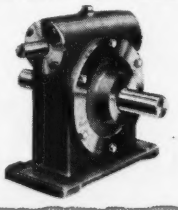
Publication 571

- a truly universal mounting, superb little worm reducer.
- standard, inverted (overdriven) vertical or D-mounting (shown with motor).
- all types and sizes available as complete worm geared motors.

**ALL SIZES AVAILABLE FROM STOCK**

Publication 5420

Light Power Worm Gears



Publication 5523

Vertical Ritespeeds

Publication 5744

Double Reduction Universal Worm Gears

es at akers of:

Dublin Glas ion, Conveyor drives, Couplings of all types, Double ester Newca gear units, Fabricated steelwork, Geared motors, Stoke-on-Tr aulic couplings, Iron, steel and non-ferrous castings, ine-cut gears of all types, Motorised rollers, Patent e-flushbushes, Plummer blocks, Shaft-mounted gear units, THE WOR al machinery drives, Spiral bevel gear units, Turbine n, V-rope Drives, Variable speed drives, Worm reduction

## CROFTS (ENGINEERS) LIMITED

**POWER TRANSMISSION ENGINEERS**

**Head Office: Thornbury Bradford 3 Yorkshire**

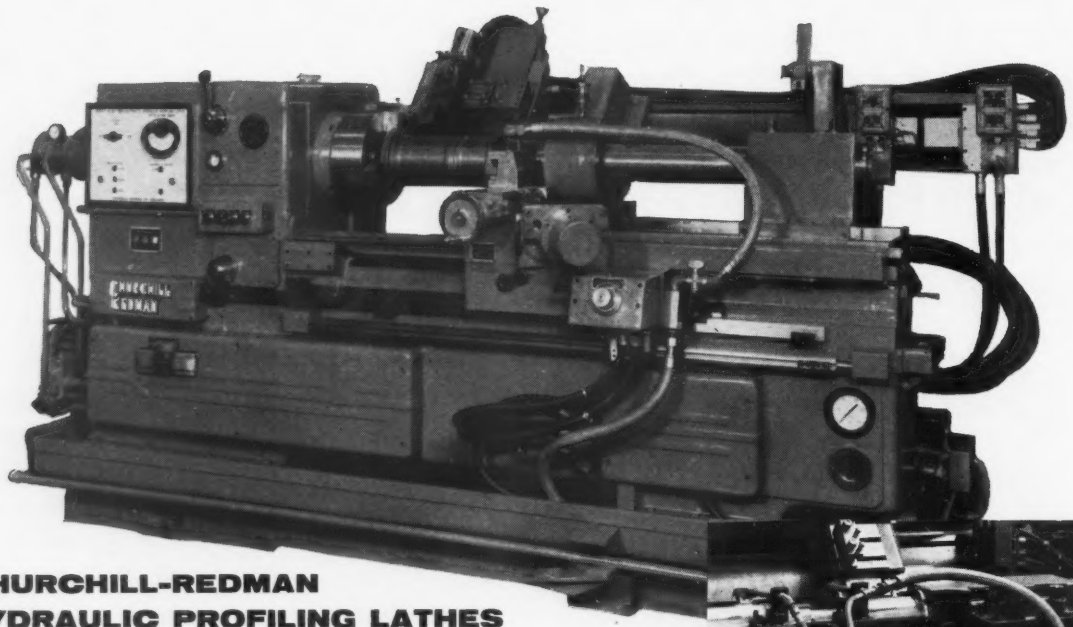
*Telephone: 65251 (20 lines) Telegrams: "Crofters Bradford Telex" Telex 51186*

CR

**OFFER**

*Faster* **TOOL SETTING**
*Faster* **OPERATION**
*Faster* **CYCLE TIMES**

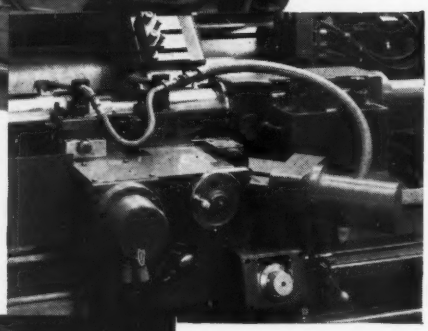
**TOOLED TO MEET YOUR PRODUCTION REQUIREMENTS**



**CHURCHILL-REDMAN**
**HYDRAULIC PROFILING LATHES**

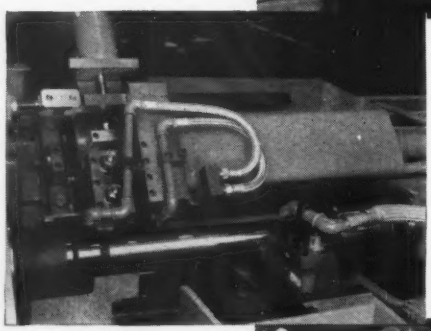
**BORING AND TURNING CYLINDER LINERS**

14″ x 40″ Model Profiling Lathe with automatic push button control and tooled to parallel bore, profile turn and part off C.I. Cylinder Liners.
**10 Minutes Floor to Floor Time** — 14″ long x 6″ o.d. Liner.



**TURNING TRUCK AXLE TUBES**

12″ x 40″ Model Profiling Lathe turning axle tubes complete. Special carriage with parallel and profile turning tools.
**4½ Minutes Floor to Floor Time** — 33″ long x 4½″ o.d.



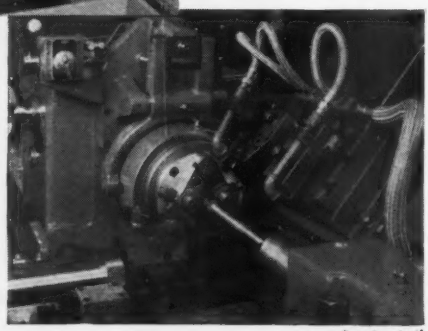
**MACHINING TWIST DRILLS**

12″ x 40″ Model Profiling Lathe turning Twist Drills complete. Rear slide parallel turns H.S.S. body. Carriage profile turns shank.
**2¼ Minutes Floor to Floor Time** — 2″ dia. Twist Drill.

CHURCHILL-REDMAN
HL Series
Model 12″ x 20″
Model 12″ x 40″
Model 14″ x 20″
Model 14″ x 40″
Model 14″ x 60″

**TURNING AND KNURLING BOLTS**

12″ x 20″ Model Profiling Lathe profile turning outside diameter complete. Special hydraulically operated knurling attachment knurls head of bolt.
**1½ Minutes Floor to Floor Time** — 1″ dia. 10½″ long bolt.



CR

DESIGNED AND BUILT BY THE LEADING PROFILER PEOPLE
**CHURCHILL-REDMAN LTD**
HALIFAX · ENGLAND
A COMPANY OF THE CHARLES CHURCHILL GROUP

Broadway/cr/1

# A revolution in space – the KING SKI-WRACKER

Now, with a KING SKI-WRACKER you can make every foot of overhead space pay its way. Specially designed to operate in confined spaces where floor-mounted equipment could not, the versatile SKI-WRACKER (exclusive to KING) can stack up to 30 ft. high and take loads of 250 lbs—10,000 lbs.
Swift, safe and easy to control, the KING SKI-WRACKER is the perfect answer when storage space is at a premium. More and more warehouses and factories are installing this unique equipment to handle plastics, sheet metal, wire, scrap metal or tabulating machines. In the film, motor car and aircraft industries, the SKI-WRACKER has proved indispensable. There's a baby SKI-WRACKER too which is perfect for handling machine tools.

**UNITS AND OPTIONAL ATTACHMENTS TO SUIT INDIVIDUAL LOADS**

KING

REGISTERED TRADE MARK

# SKI-WRACKER

*(Covered by British and Foreign Patents)*

***SEND FOR ILLUSTRATED LITERATURE TODAY***

*Fill in your name and address and post to us*

**NAME**_____

**ADDRESS**_____

GEO. W. KING LIMITED, S.18 ARGYLE WORKS, STEVENAGE, HERTS. TEL: STEVENAGE 440

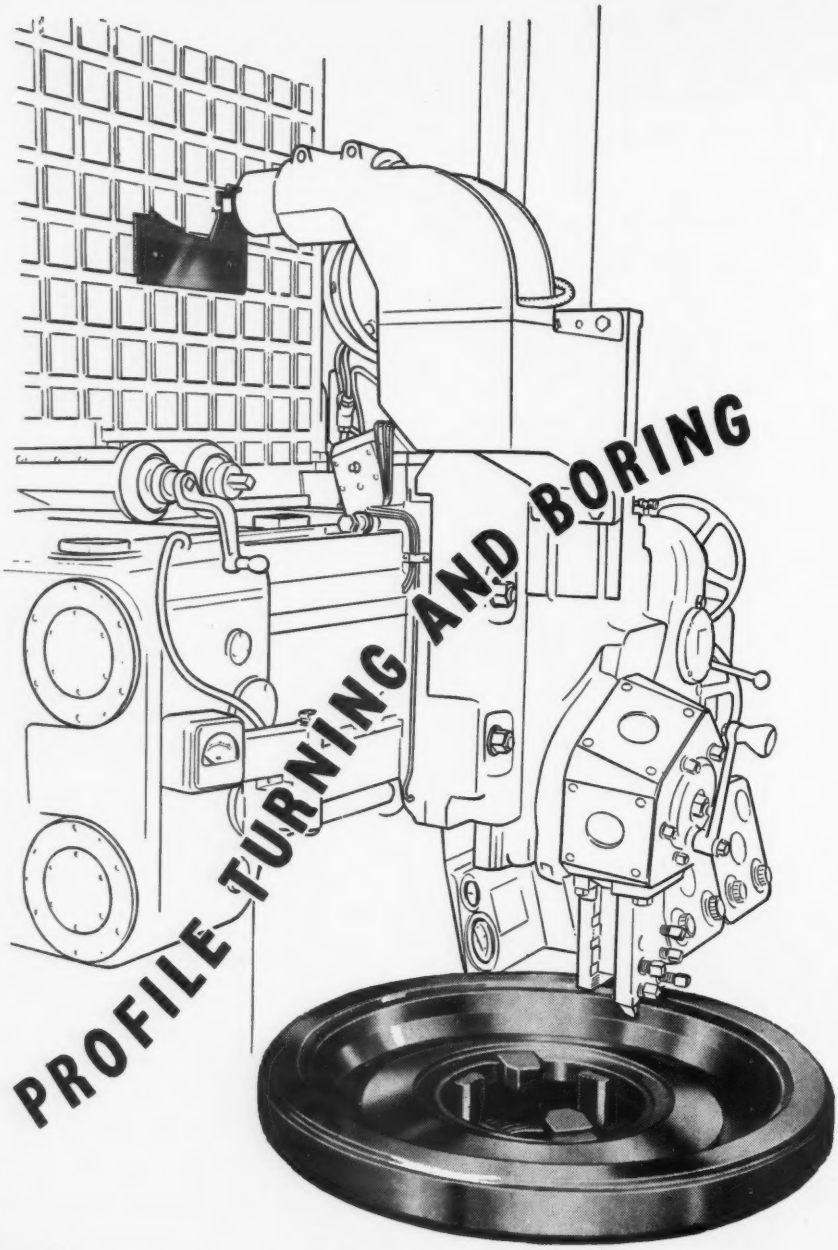
*For faithful reproduction of intricate profiles*

*automatically*

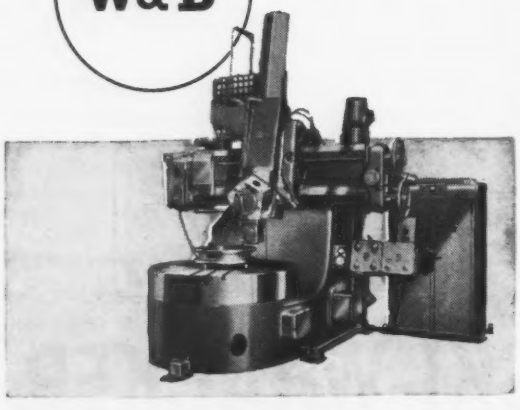
*from simple quickly produced templates*

*and reversion to manual control at will*

**W&B**



# PROFILE TURNING AND BORING



The application of electronic profile turning and boring equipment to the Webster and Bennett range of vertical boring mills opens up a wide new field of uses for these versatile machines. Although specifically designed for copying applications, when not required the electronic control may be disengaged and the machine operated as a standard machine under mechanical control.

Machine capacities range from 36″ to 72″ chuck diameter, and machines can be supplied with or without the electronic profiling equipment.

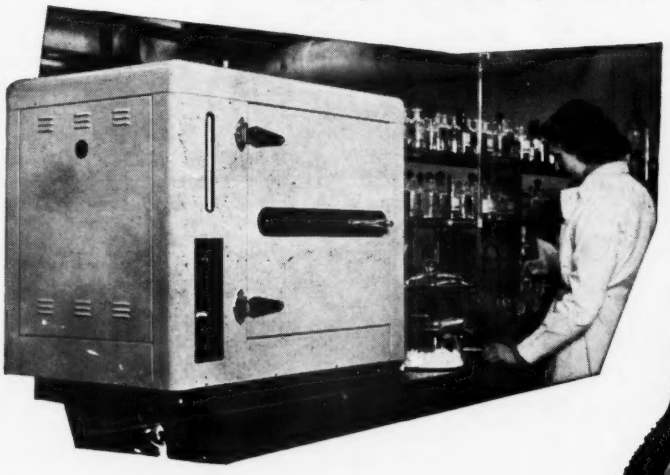
**WEBSTER & BENNETT LTD.,** COVENTRY, ENGLAND

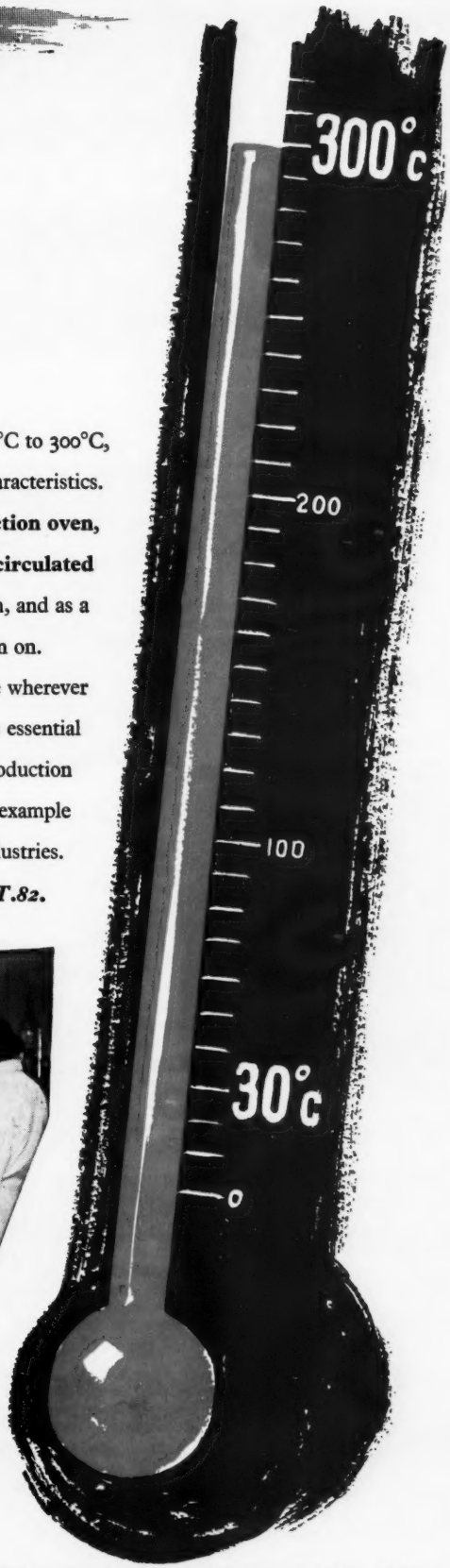
# The BTL wide-range oven

This oven covers the range of 30°C to 300°C, with excellent heat-up and recovery characteristics. It can be used in three ways—as a **convection oven,** with vent open and without fan, as a **fan-circulated closed oven,** with vent shut and fan on, and as a **forced-draught oven,** with vent open and fan on.

The oven is designed for use wherever accurate control of temperature is essential —in laboratory work or in the production of small components, for example in the electrical and associated industries.

***Write for technical leaflet BT.82.***





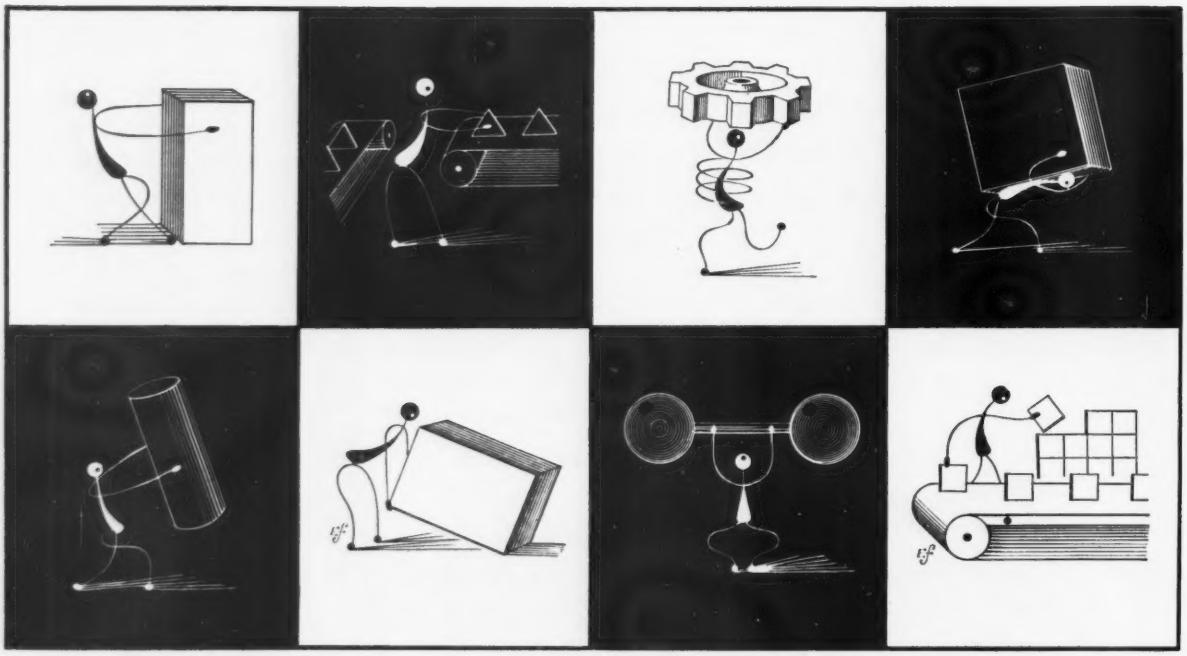

BT L

***complete laboratory service***

BAIRD & TATLOCK (LONDON) LTD CHADWELL HEATH, ESSEX, ENGLAND.
*Branches in London, Manchester and Glasgow.* *Agents throughout U.K. and all over the world.*

TAS/BT.18

# Hymatic Automation



is the name of a booklet which tells how
Hymatic Automation applies to you

199

*If you would like a copy of this booklet complete this coupon and post it to The Hymatic Engineering Co. Ltd., Redditch, Worcestershire*

**Name** .....

**Name of company** .....

**Address** .....

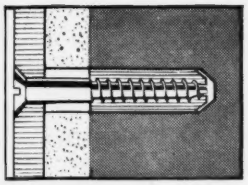
.....

**Position in company** .....

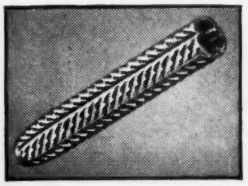
84

# RAWLPLUG FIXING DEVICES and TOOLS . . .

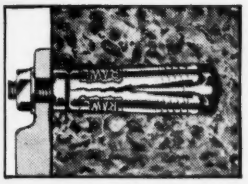
## Backed by the Name that Carries the Weight



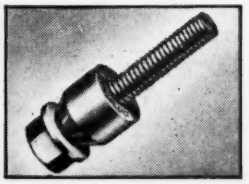
**For firm Screw Fixings.** The specially treated fibrous construction of the Rawlplug provides the most effective stronghold for wood-screws in any masonry. The simple method of making the hole, inserting the Rawlplug and driving home the screw enables firm fixings to be made quickly without mess or damage to walls or decorations. Sizes are from the tiny No. 3 to the 1″ diameter No. 30.



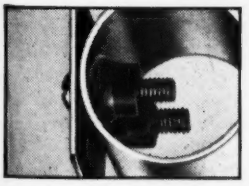
On the occasions where a metal plug is preferred or advised, such as for wet or acid situations, there is the choice of Rawlplug Screw Anchors or White Bronze Plugs, but for these Cadmium plated screws should be used.



**Heavy Duty Fixings.** RAWLBOLTS are expansion bolts which only require a hole in the masonry in the same way as a Rawlplug. By turning the bolt the metal segments are locked within the hole and the fixing will take very heavy loads with complete safety. Sizes are from 3/16″ to 1″ diameter.

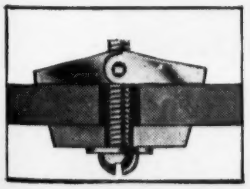


**Wet or Acid Situations.** Rawlplug Bolt Anchors and Rawltamps are made for heavy duty bolt fixings in places where the exposure to corrosion is extremely high. The Bolt Anchor can be set deep down in thick concrete whereas the Rawltamp enables a threaded insert to be fixed in shallow concrete.

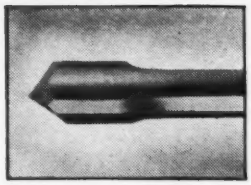


**Thin or Cavity Walls.** Proprietary building materials often present fixing problems because of being either hard and thin or thick and soft. The Rawlplug Company have devised several clever devices for making firm fixings to such materials including lath and plaster ceilings, hollow pot, panel doors, etc.

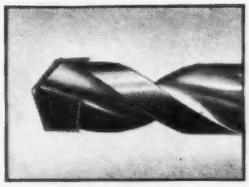
The upper illustration shows how one of the devices will make the almost impossible fixing of a metal plate to a pipe and the bottom illustration shows how the wings of a Spring Toggle spread the load over a plasterboard ceiling.



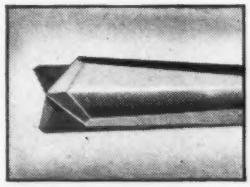
**Rawldrills.** Standard sizes for Rawlplugs Nos. 3 to 30 and Rawlbolts A. B. C. D. E. and G. Adaptable Rawldrills need only three holders for the 10 sizes Nos. 3 to 22. There is also a very useful Universal Tool-set with a knurled holder to take Universal Rawldrills Nos. 6 to 20.



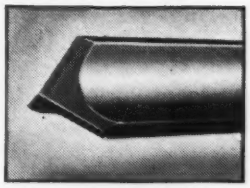
**Durium tipped Drills.** For faster, silent penetration of masonry and tiles Durium drills are the answer. They can be used in hand or suitable electric drills. Sizes for Rawlplugs Nos. 6 to 30; for C. D. E. and G. Rawlbolts, and a long series for drilling right through walls. Free resharpening Voucher given with every Durium drill.



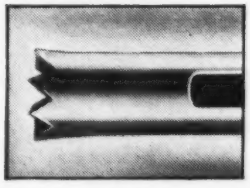
**Rawlplug Stardrills.** An inexpensive one piece tool for use on jobs needing a small number of holes. Twenty sizes from 11/32″ to 2½″ are made, of which eight are for Rawlbolts "A" to "K", and it is only necessary to quote the reference letters of the Rawlbolts when ordering Stardrills to use with them.



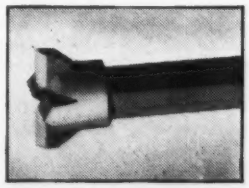
**Wall Boring Tools.** Specially designed for rapid boring right through walls. This triple fluted percussion tool with hexagon handle in one complete unit has been proved to make a ¾″ hole right through a 9″ stock brick wall in nine minutes. Lengths 18″ and 24″, diameters from 5/16″ to 1½″.



**Tubular Boring Tools.** Will bore a clean hole in soft brick wall quicker than any other hand percussion tool. The serrated edges saw through masonry and the dust is collected in the channel and ejected through the elongated slot. When working in deep holes the tool should be withdrawn periodically and the dust tapped out. Size are from ¼″ to 1″ diameter.



**Power Tools.** In addition to the hand tools listed above special Rawlplug tools are made for use in electric and pnuematic power tools. Details of these can be had on application.



**Rawlplug Fixing Devices and Hole Boring Tools are sold by Ironmongers, Hardware Dealers, Builders Merchants and Stores. If you experience any difficulty in obtaining the type and size you require please send details to the following address.**

8597

**THE RAWLPLUG COMPANY LIMITED, CROMWELL ROAD, LONDON, S.W.7**

# Adjustable Storage ... as you need it!

## RACK Interlocking U-RACKS

32/6 per unit*
EX-WORKS
*Quantity discounts available

Quickly set up or dismantled!

Lightweight for ONE MAN handling!

**U-RACK UNIT SPECIFICATIONS**

Capacity: 5 tons — Depth: 4⅛ in.
Height: 13½ in. — Weight: 20 lbs.
Width: 24 in.

**Store any length... any capacity ...and do it economically!**

Fool-proof, safe, interlocking features make RACK U-RACKS the simplest and most economical method of giving you temporary or permanent storage facilities for any length steel stock or pipe. Made of welded steel channel into units weighing only 20 pounds each, U-RACKS are easy to erect or dismantle . . . and they will provide you with years of dependable service and maximum safety.

*A RACK Engineer will gladly call at your plant to make specific storage recommendations . . . without obligation!*

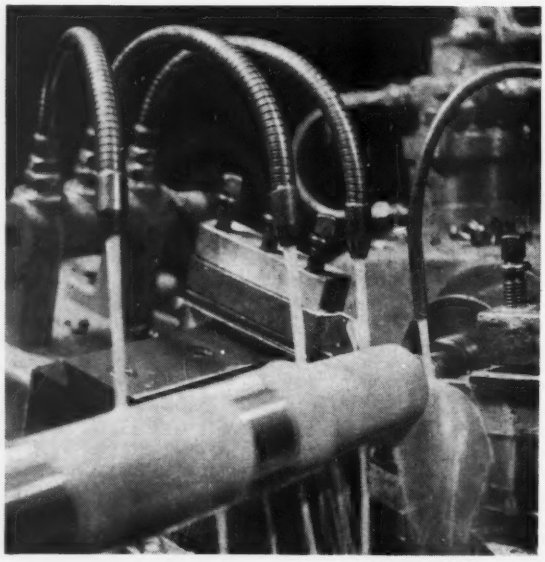
E2

**RACK Engineering Limited**
408A MONTROSE AVE.
SLOUGH TRADING ESTATE
SLOUGH, BUCKS
PLANTS: Connellsville, Pa., Gardena, Calif., Fareham, Canada and Slough, England



# There's still nothing like COOLEDGE
REGISTERED TRADE MARK

## for general machining



In the machine shops of Great Britain the name "COOLEDGE" is a by-word, known equally well by the operative as by the production engineer. Its cutting control is unique, its adaptability quite exceptional.

Moreover, due to its richer, more stable emulsion, COOLEDGE can be standardised over a very wide range of tooling operations in the sure knowledge that the average tool life is extended, surface finish is held to close limits whilst a very welcome economy in emulsion strengths is achieved.

*By asking for Publication SP.173—on your business letterhead please—you will receive up-to-date information on FLETCHER MILLER cutting fluids.*

*one of the*

**FLETCHER MILLER**

*cutting fluids*

**FLETCHER MILLER LTD., CHESHIRE.**
*Telephone:* HYDE 3471 (5 LINES) *Telegrams:* EMULSION, HYDE

CF116

# VARLEY

**DO ALMOST ANYTHING**

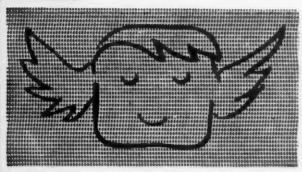
. . . and the odds are we are helping you to do it. We are specialists in design for mass production. We also design *and* mass produce to special requirements.

Some of our successes in this field:
Relays and Coils for the Aircraft Industry.
Motors for Hair Dryers.
Coils, Solenoids and Harnesses for the Automobile Industry.
Motors and Solenoids for Washing Machines.
Mechanisms for Electric Razors.
Coils, Solenoids, Relays and Transformers for Computing Automation and other Industries.

Whether we help you design (which we prefer) or produce components of your own to rigorous schedules; we believe that we can save you money and serve you better . . . Over five decades of experience is at your call . . . Can we use it for YOU.

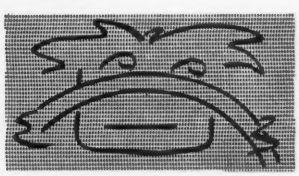
**Problem:**
Develop a special 14 watt shaded pole motor of 2,400 r.p.m. to run quietly and continuously in high ambient temperatures with a special starting torque.

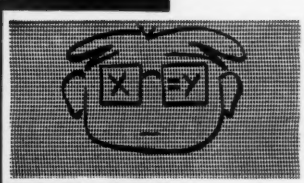
**Solution:**
Motor developed by Oliver Pell Control in less than one month. Order Placed. 4 months from order, production of 500 motors a week started. We can do this for YOU.



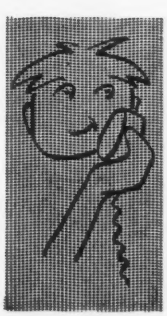
. . . fly

. . . drive






. . . compute



. . . shave

## Do almost anything...

Varley
REGD. TRADE MARK

**OLIVER PELL CONTROL LIMITED**

CAMBRIDGE ROW, WOOLWICH S.E.18, ENGLAND. CABLES: VARLYMAG, WOOLWICH. TELEPHONE: WOOLWICH 1422

OP.6C

## MACHINING

*Machining small bracket on Kearns 'S' type Facing Chuck Model*

## OPERATIONS

Snout and Line Boring — Automatic Surfacing — Face Milling — Turning — Drilling... all at one setting.

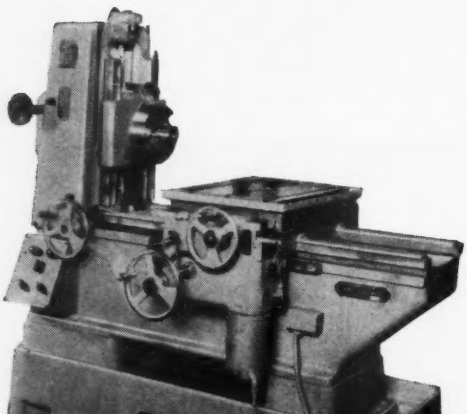
*Send for Catalogue NS*

# Kearns

## 'S' TYPE

### BORING MACHINE

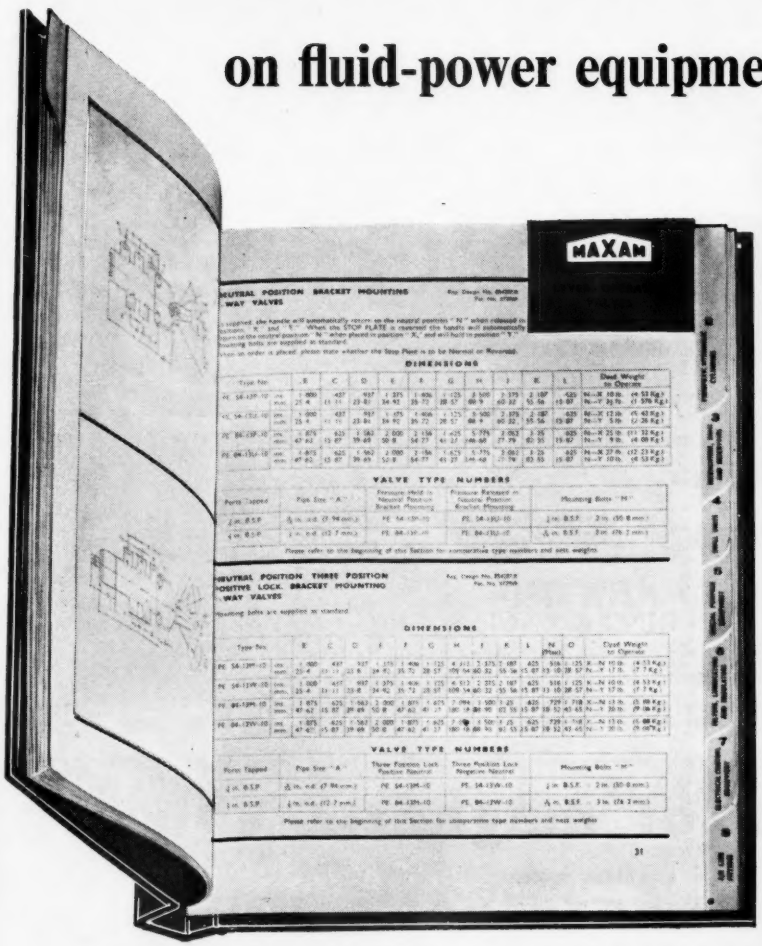
*— almost a workshop in itself*



H. W. KEARNS & CO LIMITED BROADHEATH Near MANCHESTER

KSG 1

# Maxam offers a detailed reference book on fluid-power equipment




- Lavishly illustrated with top-quality photographs.
- Full specifications and scaled draughtsmen's plans of every unit.
- Comprehensive sections on: control valves; pneumatic; hydraulic cylinders; intensifiers, rams and reservoirs; drill units . . .
- . . . special-purpose equipment; filters, lubricators and regulators; electrical control equipment; airline fittings.

***FREE to Chief Engineers, Methods Engineers, Plant Engineers, Designers, Draughtsmen, Buyers and Librarians.***

## FULL PLANS AND SPECIFICATIONS OF MAXAM EQUIPMENT

Just post the coupon below or write for your copy.
Take a tip from MAX AM and write in now, for supplies are limited and there's going to be a big demand.

## MAXAM POWER LIMITED

Camborne, England. Telephone: Camborne 2275 (10 lines)
44 Brook St., London W.1. Telephone: Hyde Park 9444

*A company in the Holman Group which has branches, technical representatives and agents throughout the United Kingdom and the world.*

To: MAXAM POWER LIMITED, CAMBORNE, CORNWALL.
Please send me the new Maxam publication, 166A.

NAME .....
POSITION .....
BUSINESS ADDRESS .....
.....

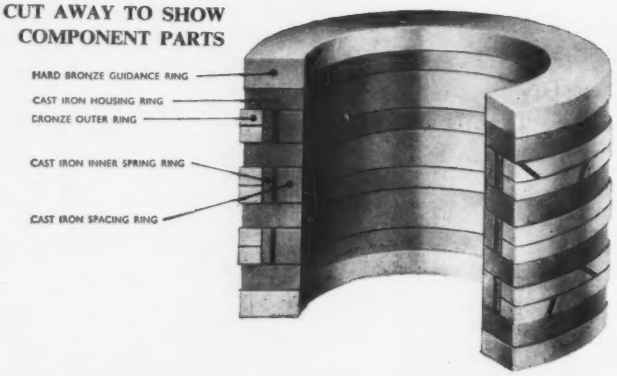
IIP 3

*Established 1893*

# Standard's

## built-up piston head for hydraulic applications

CUT AWAY TO SHOW COMPONENT PARTS




***ADVANTAGES OF STANDARD'S BUILT-UP PISTON ASSEMBLY***

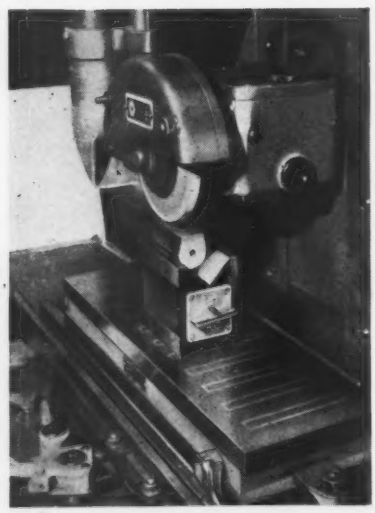
- All faces of assembly precision ground, permitting clearances to be reduced to a minimum.
- No possibility of ring distortion due to springing over solid piston.
- Any length of assembly can be built up to suit customers' requirements.

**The Standard PISTON RING & ENGINEERING COMPANY LIMITED**

PREMIER WORKS · DON ROAD · SHEFFIELD 9 · ENGLAND

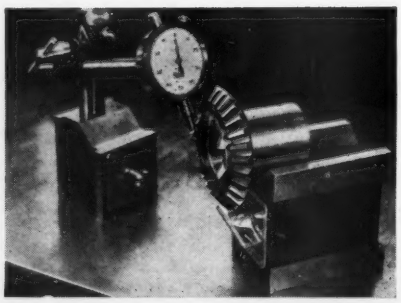
Telephone : Sheffield 42076-7-8 (3 lines) Telegrams : Ocean, Sheffield 9

# a new design of magnetic V block



* more powerful
* more convenient
* more adaptable

An indispensable item of equipment in every engineering shop, the "Eclipse" Magnetic Vee Block No. 934 is provided with two vee'd faces to hold large or small diameter work. The end is also a magnetised face and is ground square to the vee'd faces. All the working surfaces are energised at the same time by a powerful Alcomax magnet assembly.



Considerable savings in setting-up time are effected. Can be used on machine tables or on the magnetic chuck.

Inspection and marking-out applications are numerous. Magnetic Vee Blocks can also be used in pairs.

Eclipse

**the only name for magnetic tools**

Made by James Neill & Co. (Sheffield) Ltd. and obtainable from all tool distributors

PM145

THE MOST COMPREHENSIVE RANGE IN THE COUNTRY!

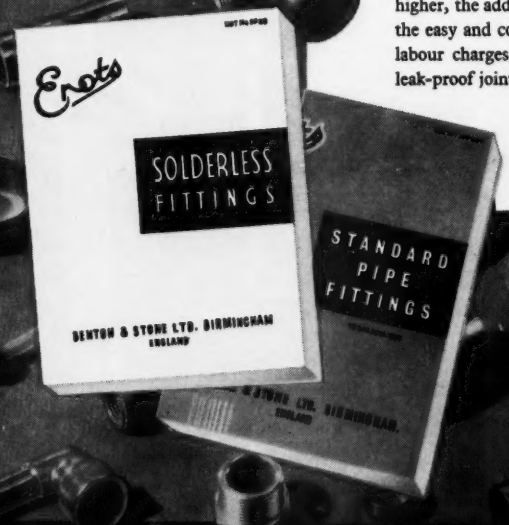
Enots SOLDERLESS UNIONS

**for the connecting of pipe-lines for use with fluids, gases, compressed air and hydraulic circuits**

*100% LEAKPROOF!*

The indisputable advantages of the brass solderless fitting as a means of connecting copper pipe lines, over the older, unsatisfactory method of employing iron pipes and screwed fittings with all the troubles of rusting and leaky joints, are well recognised and, although first cost of material is higher, the additional expense is more than saved by the easy and convenient fitting and the economy in labour charges, apart from obtaining 100 per cent. leak-proof joints with Enots Solderless Fittings.

*Write NOW for Catalogues S.F. 158 and S.P.F. 657*




**BENTON & STONE LTD., ASTON BROOK STREET, BIRMINGHAM 6.** Telephone: ASTon Cross 1905

# What d'you know ?... ABOUT STEEL

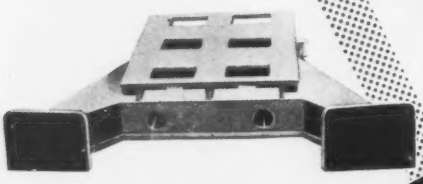
"Mr. Mac" knows a lot . . . he and the expert staff at Macready's are available to help with any steel problems you may have. Stocks exceed 5,000 tons held in a modern store for quick despatch and our own lorries deliver over a wide area of the country. "Mr. Mac" is at your service and your enquiries (and your orders) will be welcomed.

## MACREADY'S METAL CO. LTD.,

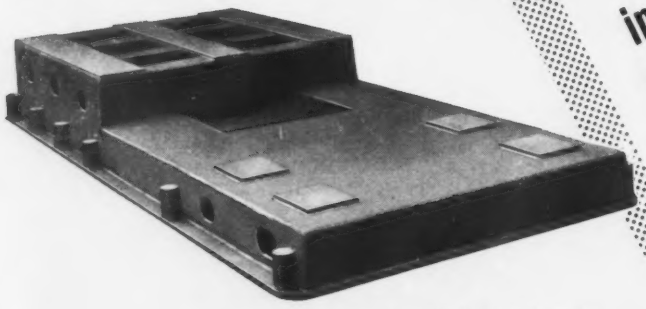
*USASPEAD CORNER, PENTONVILLE ROAD, LONDON, N.1.*

**Te'ephone: TERminus 7060 (20 lines) Telegrams: Usaspead, London, Telex Telex No. 22788**

## BOLTON RAILWAY WAGON & IRONWORKS Co. Ltd.



ALL WELDED MACHINE BED PLATE



FABRICATED BED PLATE

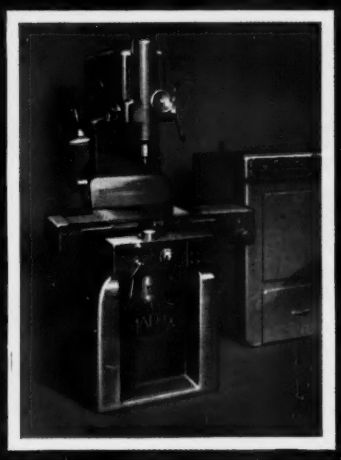
6"

1/4"

**We can profile cut any shape in mild steel from 1/4" to 6" thickness**

These two photographs of Welded and Fabricated Machine Bed Plates give a good example of how well the complications of modern machine practice can be overcome by these modern methods resulting in greater economies. Our products are clean cut and necessitate the minimum of machining and finishing. They make for larger economies in reducing the number of operations. All enquiries will receive our usual prompt attention.

460 MANCHESTER RD. BOLTON Phone BOLTON 4020 (3 LINES) TELEGRAMS 'WAGON' BOLTON



the
authority
on
MACHINE TOOLS
•
PRECISION
MEASURING
INSTRUMENTS
& GAUGES
•
PRECISION
ENGINEERING
EQUIPMENT

Coventry Gauge
& TOOL COMPANY LTD
MATRIX

Cogent

Wimet
Tungsten Carbide Balls
Hardness Testing
Tube Sizing - Valve Closure
Slideways Bearings - Metrology
Polished balls are available for these and other applications; they can be supplied as sintered for paint grinding, ball milling, etc.
Sizes from: 1/8" – 1/2" (in 1/16" increments)
5mm & 10mm for Brinell Testing
Above sizes available from stock
other sizes on quick delivery.
Wickman
WIMET DIVISION, TORRINGTON AVENUE, COVENTRY
Telephone: Tile Hill 66621

# OPERATIONAL RESEARCH IN ENGINEERING PRODUCTION

by N. A. Dudley, Ph.D. (Birmingham),
B.Sc. (London), M.I.Prod.E.

*Head of the postgraduate Department of*
*Engineering Production in the University of Birmingham*

THE postgraduate Department of Engineering Production in the University of Birmingham is charged with investigating the interrelation, co-ordination and control of the many factors involved in efficient manufacturing ; discovering and elucidatng the scientific principles upon which the planning, organisation and control of production are based ; and organising courses in the principles of engineering production for students who must be of graduate standing and have had satisfactory industrial experience.

Since its inception the Department has recognised the place of Operational Research in its studies. In 1949 its first Summer School included O.R. lectures and case studies ; in 1953 was launched the first of a continuing series of short residential courses on O.R. (Gander, 1955) ; in 1957 two Ph.D. degrees were awarded in the Department for research on O.R. techniques ; and this year the University authorities have approved the introduction of an M.Sc. Degree Course in O.R. — the first in the United Kingdom — and allocated funds for the establishment of an O.R. Library.

The purpose of this Paper — at a time when The Institution of Production Engineers is introducing Operational Research into its Associate Membership's examination — is to discuss the nature and place of operational research studies in the field of engineering production, by reference to what has been attempted and to what it is believed has been achieved at Birmingham, and to what it is proposed to attempt in the future.

## the nature of Operational Research

Concepts of O.R. are many and varied. Some definitions are synonymous with definitions of engineering production or of scientific management, some have an even wider connotation. All are agreed that O.R. is research, and there appears to be a general agreement that O.R. is concerned with " the kind of problems with which executive authorities have to deal ".

We, at Birmingham, have tended to confine the term to the use of scientific research method in providing quantitative bases for executive decisions, and we are particularly interested in the decisions of those executives whose prime and most critical task is the co-ordination " of the many factors involved in efficient manufacturing ".

In this context it is possible to conceive O.R. merely as a stage in the development of more refined, more specialised and more powerful techniques of quantitative

analysis, for although the term "operational research" is relatively new, it is well known that the application of scientific methods of analysis and measurement to industrial operations and executive decisions was pioneered by Taylor and the other fathers of scientific management some 60 years ago. The members of our M.Sc. Course in Engineering Production are introduced to O.R. techniques and thinking, in the belief that there is indeed a valid place for O.R. as an addition to the techniques available to the production engineer, but beyond that we consider not only that the operational research specialist must take his place beside other specialists in the engineering production team, but that the essence of O.R. is the research approach and that the particular techniques employed are of secondary importance.

**O.R. methodology**

The methodology of O.R. is the entire methodology of the whole field of science. The problem is defined — and is occasionally solved merely in the process of defining it — the data are collected and analysed, conclusions are drawn, and the solution tested. The tools are those of logic, of mathematics and of statistical analysis, and extensive use is made of mathematical and mechanical models which represent, with varying degrees of approximation, industrial situations.

There appears to be a cleavage of opinion between those who have come into O.R. in the post-War period, and who have been much occupied with methodology, and those who were involved in War-time O.R. and who say that there is too much concern with methodology. The latter argue that the value of the O.R. team lies merely in "turning scientists loose" on management problems. Insofar as this last statement is a criticism of preoccupation with specific techniques, we are in sympathy with it. In our new M.Sc. Course on O.R. we are endeavouring — as in the case of our existing M.Sc. Course in Engineering Production and short introductory courses on O.R. — to present a balanced picture of O.R. in which the specialised techniques are shown in their true perspective. In this connection, we are aware of difficulties arising from our advanced short courses on these specialised O.R. techniques. It is proper that our teaching and research staff should seek problems where these techniques may be applied and tested; it is clearly undesirable that our course members should be encouraged to look for problems that lend themselves to the techniques rather than to have the tool at hand for use when appropriate.

**research on O.R. techniques**

Although a recent survey of industrial O.R. projects undertaken by one of our graduate students (Lowe, 1957) revealed that, of some 260 problems, 25% required no more than comparatively simple method study and "commonsense" for their solution, statistics is now undoubtedly regarded as the first of the O.R. tools, while the special O.R. techniques that have been developed are only refinements of statistical or mathematical tools. The development and practical application of queueing, probability, Monte Carlo, linear programming and other techniques provide opportunities for industrially profitable and academically respectable investigation.

The theory of queueing has been developed considerably in recent years, and there is now a vast literature on this subject. It is applicable to operational systems having some sort of units which must be serviced, a service which must be performed on them — which may or may not be independent of the number and type of "customers" — an arrival time distribution for the customers, and an exit procedure by which the units leave the service point. The analysis of apparently simple queueing problems can become quite difficult and in such cases it is possible to find a partial answer by simulating the actual development of the queue by the Monte Carlo method. This, however, is usually a laborious process and methods of performing it mechanically are required. In some cases this has been done by using electronic digital computers, and in others by the development of special purpose analogue machines.

One of our research students (Page, 1957) has recently completed two studies of queues in manufacturing processes. The first of these was involved in determining the number of soaking pits necessary to serve a cogging mill — a problem posed by a Sheffield steelworks — where it was obvious that if there were too many pits there would be an unnecessary cost in heating and maintaining them, and if there were

too few, the mill would be kept waiting for ingots. Works data were analysed and a solution to the problem found by simulation. The solution was then generalised and presented graphically. The second study was of two types of multi-stage queue, one a production line of machines producing discrete articles and having intermediate stores of finite capacity, the other similar to the first except that the product was produced continuously by the machines so long as they were in operation.

The supervisor of this work has himself recently presented a thesis (Benson, 1957) on machine interference — a special case in the theory of queues — concerned with the problem of forecasting the duration and distribution of non-productive time when an operative has to tend a number of machines with irregularly occurring stoppages.

Another research student (Haley, 1956) is investigating industrial applications and developing methods of linear programming, the branch of mathematics which is being developed to deal with problems of choice where the object is to determine optimum operating conditions. In this series of studies it has been shown how it is possible to minimise the cost of, or maximise the profit from, for example, coal allocation by the Central Electricity Generating Board; gas production by the West Midlands Gas Board; and the siting of depots for Thomas Hedley & Co. Ltd.

**mechanical models**

Several mechanical and electrical models have been developed in connection with the above studies to reduce and simplify the work of computation. One of these analogue machines—christened TOM (Transportation Optimisation Machine)—was demonstrated by Mr. K. B. Haley at the Institution's Summer School on Operational Research in 1957. It was developed with the assistance of Dr. E. R. F. W. Crossman, at that time Research Fellow in the Department of Engineering Production, and is described in the Proceedings of the first International Conference on O.R. (Stringer and Haley, 1957). The machine, a system of strings, weights and pulleys, enables the most economic routes to be selected in the classical transportation type of linear programming problem.

To assist in the study of machine interference problems, a graduate course student (Hartshorne, 1957) last session designed and constructed a machine which simulates the operation of a battery of machines. A more refined model is being developed by one of our present students (Sagar, 1958), who has coupled, and is in other ways modifying, two electrical calculating machines for this same purpose.

There is enormous scope for ingenuity in the design of analogues which have advantages over conventional and general purpose calculating machines and for use in circumstances in which it may not be possible or economic to use an electronic computer. The possibility of developing such models not only stimulates the interest of young production engineers in O.R. problems, but promotes the understanding of O.R. techniques.

**case studies and project work**

It has already been noted, however, that the particular techniques employed in O.R. are considered of secondary importance and that the essence of O.R. is the research approach. Another characteristic of O.R. is that it is usually regarded as a team activity in which scientists of many disciplines participate, and in which the diversity of knowledge and background assists in the solution of complex problems.

Therefore, in association with industrial O.R. departments, we organise group case studies and project work for our graduate course and short course students. In this way the strategy of O.R., as opposed to its tactics, can be practised and understood. We use only "live" case studies, that is, the study of current industrial problems in their actual context. In the short courses limitations of time prevent the testing of solutions except in those few cases which our Staff Tutors are able to follow up. (One of our group reports * was used — without acknowledgement — as the O.R. case study at the recent International Conference on Management Education and Training). In the case of the graduate course students, up to three months' full time may be devoted to a particular study.

* University Institute for Engineering Production O.R. Group report entitled: "How to Run a Bassoon Factory", reproduced in the 5th International OEEC Conference Papers on the "use and interpretation of quantitative data — its impact on management as a field of learning" (April, 1958).

Industrial companies and their O.R. staffs are exceedingly co-operative in providing facilities for practical studies and in giving details of their O.R. organisations and projects.

**O.R. as a University discipline**

The M.Sc. Course in O.R. — admission to which is limited to six post-graduate and post-industrial experience students — has just been launched. Although this may be regarded as a natural and logical development of our activities, emerging from our long-term research on O.R. techniques and from our series of short courses for senior executives and O.R. personnel, it also indicates the recognition and acceptance by the University of O.R. as a scientific discipline.

Although there has been an unfortunate tendency for science to become progressively more departmentalised, resulting in many scientists having little knowledge of parallel disciplines, the underlying unity of the scientific method has been demonstrated by O.R. in solving problems based on analogies which come from many scientific disciplines, thus indicating the structural unity of apparently dissimilar problems. The search for such a structural unity is an obvious function of a University, and this is really the exciting thing about O.R. from an academic point of view.

## REFERENCES


Benson, F. (1957). "Machine Interference: a Mathematical Study of Some Congestion Problems in Industry", Official Degree Thesis, Department of Engineering Production, University of Birmingham.

Gander, R. S. (1955). "Courses on Operational Research", Operational Research Quarterly, 6, No. 3, 118 - 119.

Haley, K. B. (1956). "Industrial Applications of Linear Programming" M.Sc. (Qualification) Thesis. Department of Engineering Production, University of Birmingham.

Hartshorne, J. M. (1957). "Machine Interference", unpublished report submitted as part requirement for M.Sc. (Eng.Prod.) degree, University of Birmingham.

Lowe, D. (1957). "Industrial Operational Research", unpublished report submitted as part requirement for M.Sc. (Eng.Prod.) degree, University of Birmingham.

Page, E. (1957). "A Study of Queues in Manufacturing Processes", Ph.D. Thesis, Department of Engineering Production, University of Birmingham.

Sagar, V. S. A. (1958). "Machine Interference" — report in preparation. Department of Engineering Production.

Stringer, J., and Haley, K. B. (1957). "The Application of Linear Programming to a Large-Scale Transportation Problem", Proc. First International Conference on O.R., Oxford. English Universities Press, pages 109 - 122.

# AUTOMATIC EQUIPMENT FOR JOBBING WORK

Three Case Studies
presented at the
Production Conference,
Olympia, 19th May, 1958
and followed by
open discussion

## 1. Batch Production Automation

by Ian Nickols, A.M.I.Prod.E.

A FEW years ago we were considering putting some form of individual incentive scheme into a small firm employing about 40 people. After receiving conflicting advice from a number of different sources, the only thing we were quite certain about was that we should have to be very careful.

Before casting in our lot with any particular work study practitioner, we decided that an elementary form of methods charting was well within our own capabilities. By giving up two or three hours a day for several weeks, we hoped to find some kind of pattern emerging from the charts which would enable us to see more clearly what a consultant, or even a full-time trained man on our staff, might enable us to achieve without the paper work becoming unduly top-heavy.

It was enjoyable making materials flow charts, and even before the ink was dry on the paper, we began thinking of hundreds of pounds' worth of conveyors, hoists, pallet trucks, etc., which in our enthusiasm we had little doubt would soon save a great deal more than their cost; but, perhaps fortunately, our bank manager was curiously unmoved by such arguments.

### the 'man-machine' chart

The most useful of the elementary "tools" of methods study, therefore, eventually proved to be the simple but effective "man-machine" chart. On these we recorded the various operations against a suitable time scale, and in two columns recorded when the man was waiting for the machine to complete some automatic part of its cycle, when the machine was waiting for the man to do something before it could get on with its work, and when they were both waiting for something or somebody else quite different. The pattern which emerged from these charts soon became so interesting that we never thought any more about individual incentive schemes.

We concentrated instead on grouping together each operator's idle periods and aimed at leaving him

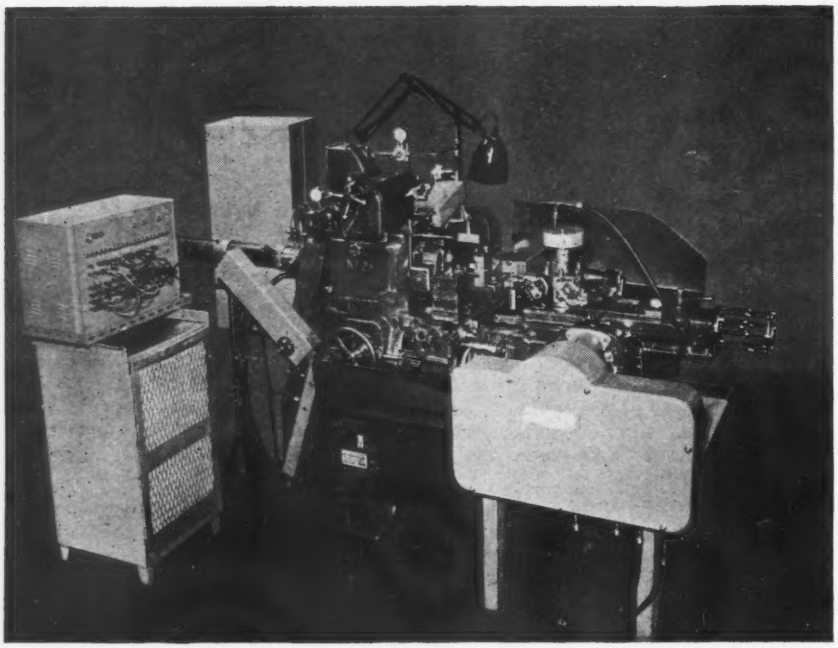


**Fig. 1. Nickols automatic control equipment applied to a Herbert 2D capstan lathe.**

the maximum possible period of "time off" in any particular machine cycle. After studying the operator's movements to see which of them could most economically be made automatic, we discovered that some were peculiar to each particular component; but that the majority consisted merely of winding handles or working levers in various sequences.

We found that the movements peculiar to a particular component were usually concerned with positioning it in a fixture or chuck. Special fraizing or checking for concentricity might be necessary here, and if special jaws or platens had to be made for automatic loading, not only would the cost of tooling for that particular batch be increased considerably, but the work could only be put in hand after the order had been received, thus tending towards increased delay in delivery.

We, therefore, accepted as a fact that when versatility was important, there was probably no more economical loading device than a pair of human hands — with or without the aid of a hoist. The loading device was only usually wanted at the beginning and end of the cycle, however, and the rest of the time the operator just stood winding handles or pressing buttons; but because something needed his personal attention every half-minute or so, he seldom had any continuous free time worth using.

On several occasions when fairly long runs were involved, we made more or less elaborate automatic devices for avoiding certain of the more tedious hand movements, particularly when a nearby machine also happened to require only part time attention so that the two could conveniently be grouped together under the care of one operator.

At this stage there was, unfortunately, no very clear plan of campaign, and in almost every case these gadgets seemed to be special to one particular component. Although some proved economically more satisfactory than others, most of them suffered from the disadvantage of having to be built after the production layout had been planned, and they had to be fairly extensively modified for different components or were eventually abandoned altogether.

Further study of man-machine charts nevertheless confirmed the tremendous potential savings that could be expected if, as a matter of deliberate policy, operators were freed from the necessity of standing by machines during that part of the cycle when they merely had to turn handles and press knobs. We, therefore, persevered with our experiments, although it soon became clear that on certain machine tools the sequence in which the controls have to be operated varies considerably from component to component.

This case study is devoted to capstan lathe operation not merely because versatile capstan lathe actuators are now available commercially, but because hardly any problem is in fact as complicated in this respect as that of programming the wide variety of control movements necessary to produce different components on capstan and turret lathes. Once the reasoning behind sequence control is thoroughly understood, other machine tools can equally easily

be adapted to tackle batch work with the optimum degree of automation.

A machine which has eventually emerged after four years of steady development is illustrated in Fig. 1. The control panel is shown in Fig. 2. In the hand operating position, used for setting or some very special one-off job, each switch or push-button operates a particular function, as for instance "Feed Turret" (via a solenoid valve, air cylinder, and rack and pinion mechanism), or "third speed" (via contactor switches for the standard Herbert 2D pole change motor). There are 26 separate functions on this particular machine, but there could equally well be more or less according to the type of work that it is expected to be able to tackle.

Some of the functions, such as motor speed changes, engagement of mechanical feed gears (via solenoid valves and air cylinders) locking of turret clamp, etc., may be assumed to take place more or less instantaneously, but others such as feed turret, feed cross-slide or any movement on which an interlocking check is required, for instance, "collet open" or "collet shut", are provided with "signals" to feed back the information that the relevant movements have actually been completed. These signals usually take the form of micro-switches, but could equally well be photo-cell units or automatic sizing gauges.

Each function and each signal has a completely separate circuit brought up to its individual switch and plug socket at the top of the control panel. This makes them easy to test if there is ever a suspicion of trouble.

For automatic operation, the required functions and signals are connected by means of plug links to rows of sockets in the lower half of the control panel. A stepping switch energises them all in turn, the four sockets set vertically at the left being energised first, then the second four being live at the next step, and so on. When setting up, the required functions are plugged in at each step in the sequence, and also at each step any one signal must be made live. It may now be a fraction of a second or several minutes before a message is received back from the signal — suppose this is a micro-switch — but when the contacts close, the stepping switch steps, and the next column of four sockets becomes live.

The operator who was displaced from the first machine to be made automatic at Messrs. Andrew Hyslop Ltd. last year was setting the machine within a matter of weeks. He had soon completely mastered the plug layout, so that although the original intention had been to work these out in the planning department, it is now taken as a matter of course that when the tooling layout has been decided, the setter will be able to plug them in in the right sequence all on his own.

### several advantages

Not only savings in cost, but improvements in tool life, accuracy and finish have resulted from the use of controlled feeds and consistent pressure against the dead stops. Threading has also improved, and there is never any down time due to breakage "because the operator got tired and made a mistake".

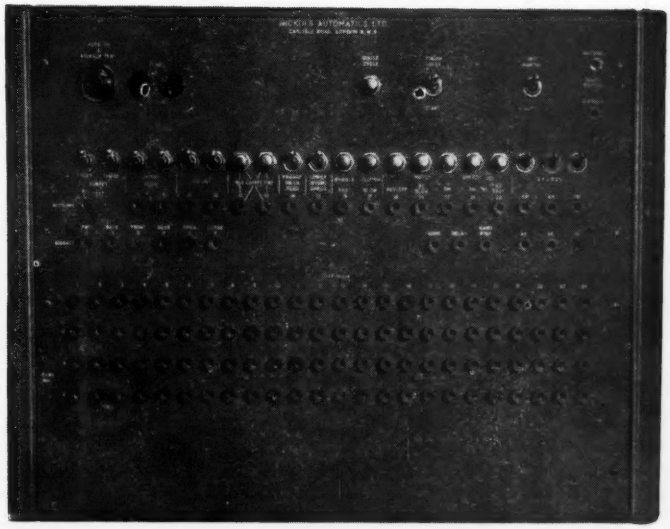


**Fig. 2.**
**Setting panel for Nickols sequence control.**

At first setting time tended to be longer, but within a few weeks it was very nearly as quick on components which had previously been set up on hand operated machines by the same man. The original operator was attending two machines and increasing in skill owing to his concentration on setting. Because the basic nature of the machine was unchanged and thus familiar to him, he was soon quite at home with the business of setting stops and arranging plugs, and this gave him extra incentive to study the technique of grinding tools.

A screwed component made from $1\frac{3}{16}$ in. brass bar used to take an average time of 3 minutes, including setting up, when the batch size was 1,000. With automatic capstans, the overall time is 90 seconds per component. Another component made from $1\frac{3}{8}$ in. brass bar used to take $2\frac{3}{4}$ minutes when the batch size was 1,000. This now comes off in 85 seconds, including setting. There are many other instances of brass and mild steel components in this firm where savings of between 25% and 50% can be shown.

At Oxted Mill Ltd., where the machines were originally used, aircraft bolts made of S 96 high tensile stainless steel have been economically manufactured in batches of 150 - 300, and nearly 500,000 small rollers to a difficult small arms specification were made with less trouble than several other firms have encountered when using conventional cam type automatics.

Perhaps the most impressive testimonial, however, is completely unsolicited. Messrs. David Brown Industries Ltd., Tractor Division, has long been interested in this project, and became the first completely unbiased customers when commercial deliveries began just before last Christmas. We should like to express our thanks to them for allowing us to reproduce the following representative figures:

**Costings of certain representative components at David Brown Industries Ltd., Tractor Division.**

28TH MARCH, 1958

| *Batch size* | *Description* | *Old method* | *With Nickols equipment* |
|---|---|---|---|
| 2,000 | Spherical washer | 2.21d. | 1.32d. |
| 500 | Special bolt | 3.80d. | 2.13d. |
| 500 | Roller | 2.51d. | 1.17d. |
| 500 | Pin | 1.48d. | 1.035d. |
| 2,000 | Dowel | 2.15d. | 1.035d. |

# 2. Automatic Component Loading and Unloading through Power Presses

by J. P. Udal

THE optimum production from a power press is only obtained when it is performing a working stroke at every revolution of the crankshaft, and the crankshaft is in continuous motion without disengagement of the clutch at the end of each stroke.

So far as the average press in the average press shop is concerned, there are considerable periods during each week when it is making no productive strokes at all, because the tools are being changed or tried out. The reduction of these periods to a minimum is obviously important in relation to efficiency, but this depends on planning and not on technique. Although it is worth mentioning here that, if an improvement in technique is introduced which gives more efficient production while the press is running, but requires increased setting-up time, it is important to be sure that the production increase more than off-sets the extra standing time.

Assuming that the press is in production, the optimum condition is reached throughout the whole range of sizes of press, on operations from strip or coil stock, whether these are simple blanking operations or multi-stage operations with follow-on tools.

The position is very different, however, on operations involving the location and removal of individual components from the press die. Under present-day conditions, the bulk of these operations is carried out by hand with direct hand loading of the die, and in more cases than I think really necessary, by direct hand unloading also.

Except on the very largest presses with long strokes, this method of working demands discontinuous operation of the press with disengagement of the clutch at the end of each stroke, and a pause of varying duration before the clutch is re-engaged. The degree of efficiency obtained varies with the size and speed of the press, i.e. it is lowest on short stroke high-speed presses which have speeds in the region of 150 s.p.m. and on which the average operator is doing very well to obtain 30 productive strokes per minute.

On larger presses the efficiency ratio is not so low, but is nevertheless low enough to create a wide field of use for mechanical loaders and unloaders, provided that these can be designed and made to give optimum, or near-optimum, production efficiency, and are

flexible enough to deal with a wide variety of components and operations, with increases in setting-up time which are so small that they are absorbed in a short production run.

**hand feeding**

If I may diverge for a moment on to the subject of hand feeding, an opinion is still held in the U.K., although not so widely now as it used to be, that the use of guards to the standard demanded officially has slowed down production rates. There is, in fact, no evidence in support of this view, and observation of the rates achieved by operators in this country as compared with their counterparts in America and on the Continent, shows that, in general, our rates are the better.

There is, on the other hand, some very convincing evidence about accident rates. In Great Britain, press accidents have steadily declined and now total a little over 200 per annum. In 1956 the official figure was 236; whereas in Western Germany, I was recently told authoritatively that the annual figure is around 2,800. I would think that the number of presses in the two countries is about the same.

My firm has been making loaders and unloaders for some time now, concentrating mainly on units suitable for larger presses, and our exhibit shows one of each of these units operating in conjunction with a press which, although it is a dummy, represents dimensionally a typical double-sided single crank press of around 200 tons capacity and 36 in. between the uprights. Presses in this range run at speeds between 12 and 30 s.p.m. depending largely on the length of stroke.

The size and weight of the components dealt with by such presses, and their capital cost relative to labour costs, lead as a rule to the use of two operators where hand loading and unloading is employed, in order to get an increased production rate. The operators stand on opposite sides, one loading and the other unloading the components. It is immediately obvious that there is an opening here for an automatic unloader, as by replacing one of the two operators this will halve the labour cost, assuming that the production rate remains the same. In fact, experience shows that an efficient unloader increases the production rate.

The components are removed from the die earlier than is possible manually, and in completely consistent rhythm with the movement of the press slide. The feeding operator is thereby encouraged to keep pace as far as possible with the mechanism facing him on the other side of the press.

**specialised unloaders**

Specialised unloaders have been used on power presses for many years, as also has air blast ejection for small and light components, but the use of the flexibly designed unloader, intended to form part of the equipment of the press rather than of the individual tools, was originated by the late Harry Sahlin of the U.S.A. with his well-known "Iron Hand".

Our apparatus looks nothing like the "Iron Hand" and possesses different, and I hope better, characteristics of accuracy, reliability and ease of setting, but I feel that it is only right that I should mention Mr. Sahlin's name as the originator in the conception of this type of equipment.

I hope that I have made it reasonably clear that there is an economic justification for the use of an unloader wherever manual unloading is now used, and provided no cheaper and simpler mechanical unloading system is available (I am thinking here of the compressed air blast). Even if only one operator is employed on a press, the unloader will justify itself, not by operator replacement, but by speeding up the production rate.

Considering the design of the unloader exhibit in detail — it has three separate motions. It is convenient to consider the start of the cycle at the cycle at the position — carriage forward, jaw retracted. The sequence is then as follows:-

1. jaw run forward and close on component;
2. jaw lift with component;
3. carriage main traverse, removing component from beyond area of press bed.

All these motions are obtained by compressed air with three solenoid-operated valves feeding cylinders in the right sequence.

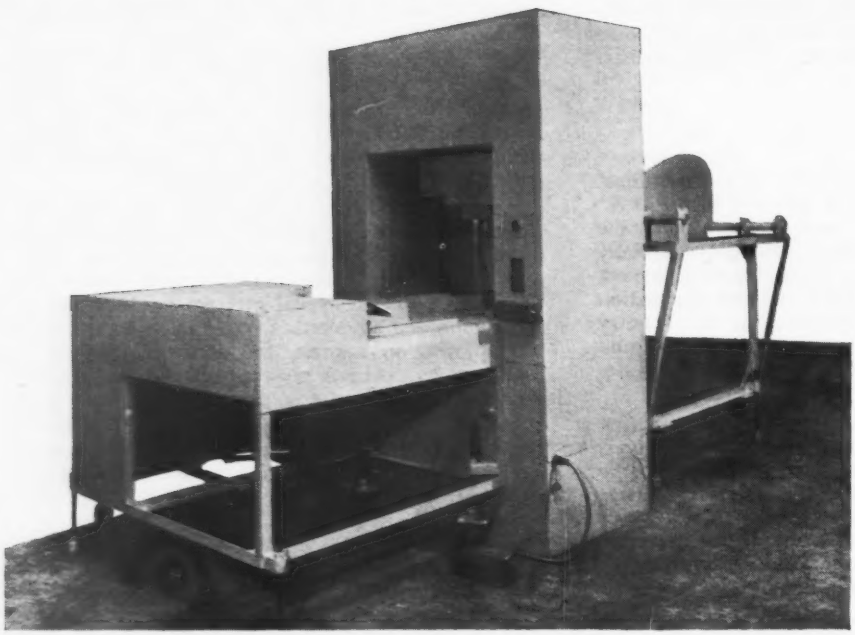
At the end of the withdrawal travel, a switch is operated which reverses all the valves so that the jaws open and lower and the carriage returns to the start position.

The control system of the unloader relative to the press is simple and can be reduced to one switch operated by the press motion at the correct point in each stroke, as the unloader is only required to function when the press makes a stroke.

The control switch operates the solenoid valve, which controls the motion "jaw run forward and close". The control of the valves for the two subsequent motions is obtained through time delay relays set to give the appropriate time lags. All the valves are held in their operating positions by holding relays until these are tripped out by the reversing switch.

An alternative system of control is provided by the Masterotor which is included in our exhibit. This is basically a multi-point control switch. It was designed in the first place for use on large and comparatively slow-running presses, where it is desirable to start and stop various subsidiary motions during the course of the press stroke. These motions can include the lift of ejectors, the rise and fall of component location blocks, and the movement towards and away from the tools of loaders and unloaders and the switching on and off of automatic lubrication.

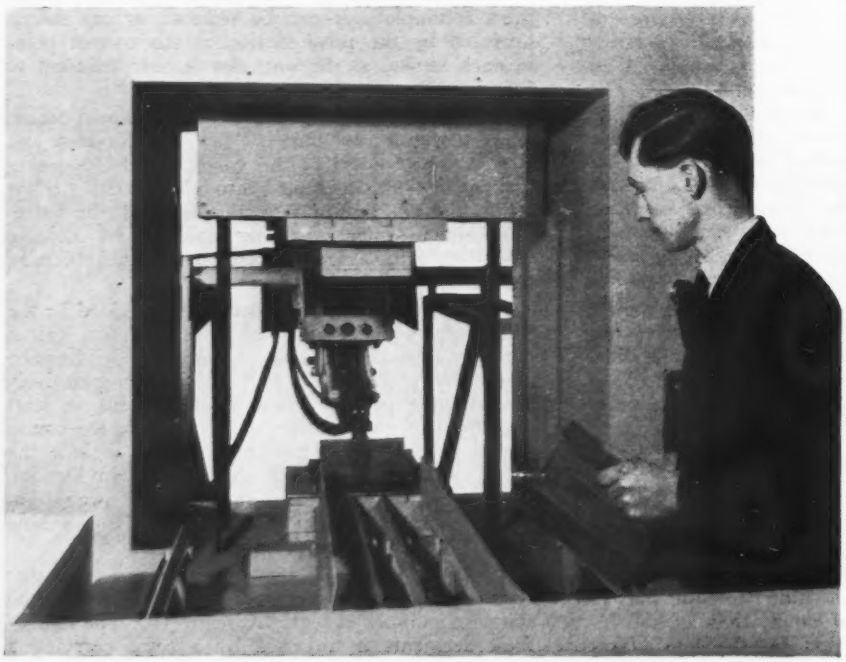
The unit consists of two parts; the first is a disc type commutator divided radially into segments, the standard number of segments being 180. The face of these segments is traversed by a rotor carrying a



**General view of press with loader (nearside) and unloader (far side). Note shrouded toe switch which gives operator complete control.**

carbon brush, the rotor being driven one to one from the press crankshaft. The movement of the rotor over the segments, therefore, gives the effect of a switch operation at each 2° of crankshaft rotation. In terms of time on a press, running at 12 strokes per minute, the spacing between steps is 1/36th of a second.

The second part of the unit is a board in which are mounted 180 sockets, each of these being wired to a different segment on the commutator. Flexible lead switch plugs are arranged so they can plug into any socket and it is thus possible to get a switch signal at any desired point in the crankshaft rotation simply by plugging in to the appropriate socket. The convenience and saving of time on this system as compared with setting adjustable cams and limit switches is very substantial. Another advantage is,



**Loader has fed component on to the die. Unloader jaws are waiting to run forward and grip component's rear edge.**

that the rotor can be placed in the most convenient point for driving, and the plug panel where it is most convenient for access, with a multi-core cable connection. The only member of the unit subject to wear is the carbon brush and the duty on this is comparatively light, so that Masterotors are proving extremely reliable under normal press shop conditions.

The loader which we are showing is not completely automatic, in that it requires an operator to feed it with individual components. At first sight, it may seem that the apparatus is incomplete unless it includes a transfer feed from a stack of components, thus freeing the operator from constant attendance at the press but, in practice, it is usually desirable to retain the operator to monitor the working of the press and auxiliary equipment in order to bring the moving parts to rest should trouble develop. The point here is not that trouble is a frequent occurrence, but that its consequences on a power press can be serious, unless quickly checked.

**giving the operator confidence**

Once it is agreed that the operator should be in constant attendance, it is logical to employ him to feed the loader and thus avoid one stage of mechanism. The operator is given control of all the motions by means of a normally off toe-operated switch which he must hold depressed in order to keep things running. We have found this "dead man's pedal" gives the operator confidence, as he can make a stop at any time in the simplest possible way by simply moving one foot.

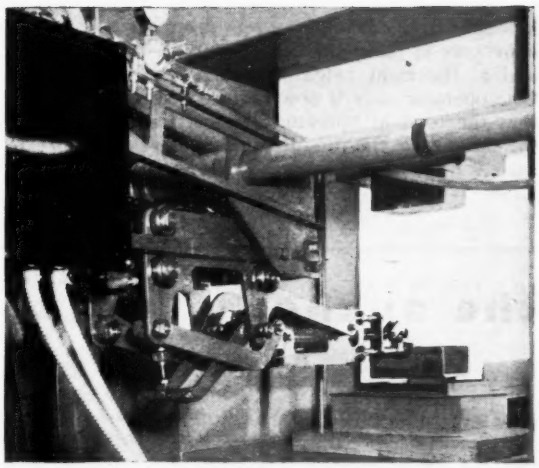
The inter-relationship of the loader and the press is more complicated than in the case of the unloader. Basically, the position is as follows:

The loader motion is initiated by manual operation of a button switch. Having loaded the component, the return movement of the loader operates a switch which causes engagement of the press clutch. When the press reaches the correct point in its stroke, it operates a switch which sets the loader moving forward. Press and loader, therefore, keep each other moving until operation of the stop switch. The press operating switch gear on the loader is designed so that if the loader cycle is sufficiently far advanced before the press has completed its stroke, the press motion is continuous. Failing this, the press clutch is re-engaged with the minimum of delay.

The economic justification of this type of loader lies in the increase in production rate provided by its use. This can easily amount to 100%.

Blanks are simpler to load than formed components and fortunately they are the pieces where increases in the production rate pay the best dividends. This is because the blanks are normally fed into a double action press at the start of a production sequence, and this press runs more slowly than the single action presses used for the following operations.

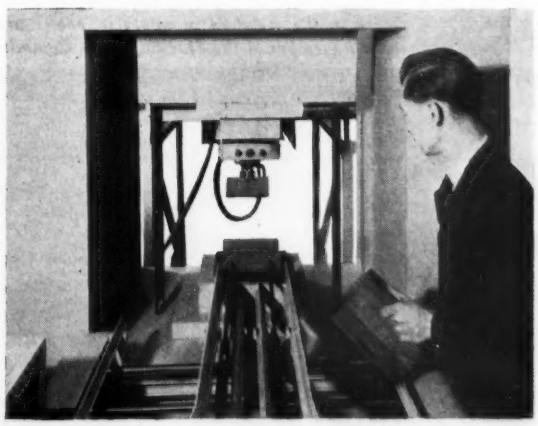
It works out very well, therefore, to use a blank loader feeding a double action press and run this continuously with manual feeding of the presses on the following operations, which because of their greater speed can operate intermittently and still keep pace with the double action press.



**Detail shows unloader jaws at point when component has been gripped and lifted from die.**

As an example of the benefits of this type of equipment, I have been told the following by a well-known producer of medium/heavy pressings, largely for the motor trade:

The old production system was on a batch basis using double-sided presses with operators at front and back loading from, and unloading into, stillages which usually needed trucking round the shop between operations. On the new basis, the presses have been installed in the shop in line astern in the right order for the work to flow down the line. Each press has been fitted with one of our automatic unloaders which works in conjunction with ejection equipment built into the tools. The leading press has been fitted with an automatic blank loader.



**Unloader is about to release component which is now clear of press bed. Meanwhile loader has fed component accurately on to the die.**

Thought and care have been taken in the use of conveyors to carry the components to the right spot and at the right height for each loading operator. One operator only is now required for each press so that the total of operators has been halved and, at the same time, the production rate has been approximately doubled, i.e. from 300 components per hour to 600 per hour. Setting time has increased to some extent but only sufficiently to offset a very small fraction of the production advantage gained. The loader and unloader units and conveyors are flexible enough to deal with all the work required from the line of six presses, and when a particular press is not required, the conveyors are arranged to by-pass it.

## the authors

*Mr. Nickols is a director of Nickols Automatics Ltd; Ian Nickols Ltd.; and Oxted Mill Ltd. He was educated at Eton and Trinity College, Cambridge, and entered industry in 1937, by way of a leather tannery. At the end of the War he was in charge of a R.E.M.E. vehicle repair shop in Nairobi, but after a brief period as works manager of a civilian garage in London, he transferred his interests to machine tools.*

*He soon became interested in grouping together various periods of machine self-act throughout any particular operation cycle, and evolving simple sequence control mechanisms to actuate the existing machine levers, thus giving operators longer periods of leisure. The fully automatic capstan lathes which form the subject of this case study are a logical development of this approach to the problem of fairly utilising idle operator time, revealed by man-machine charts.*

*Mr. Udal took over the Managing Directorship of J. P. Udal Ltd., safety guard manufacturers, 24 years ago on the death of his father, Mr. J. P. Udal, who founded the firm in 1923.*

*Mr. Udal was educated at King Edward's School, Birmingham, where he held a Foundation Scholarship, and then received a practical engineering training at the works of Messrs. Bradley & Turton Ltd., Kidderminster, prior to entering the family business.*

*His firm can claim to have played a leading part in the improvements which have taken place in the standard of safety in power press work in the United Kingdom. Mr. Udal has been a member of the Standing Joint Committee on Safety in the Use of Power Presses since its formation in 1946.*

*Mr. Puckle, who is Chief Lecturer with E.M.I. Electronics Ltd., has spent some weeks lecturing and broadcasting throughout Australia and in Singapore. He has done research work on radio, television and radar. He translated a book, "Television Reception", from the German, and wrote "Times Bases", which has been printed eight times and translated into French, Dutch and Russian.*

*He has served as a member of the Radio Section Committee of the Institution of Electrical Engineers and has been awarded its Duddell Premium and has shared its Radio Section Premium with Mr. L. H. Bedford. He has also served as Secretary and later, Chairman, of the Television Society.*

# 3. Prototype E.M.I. analogue numerically-controlled milling machine at the Bristol Aero Engine works

by O. S. Puckle, M.B.E., M.I.E E.

*This case history is a very unusual one and it therefore makes rather an interesting story. Normally, a case history about a machine relates to a production machine; this relates to a prototype in its early stages. This story shows how a purchaser collaborated with a supplier in overcoming troubles on a new and complex equipment. It is also a tribute to the purchaser and, in particular, to the Assistant Works Manager, whose refusal to make hasty decisions has resulted in harmonious relations and a job well done.*

**introduction**

The Development Manufacturing Division of Bristol Aero-Engines Ltd., Filton, have occasion to make templates of various shapes and sizes for use in conjunction with Fischer and with Monarch lathes. They decided to investigate the possibility of using a numerically controlled milling machine for this purpose. As a result of reaching this decision, they entered into negotiations with E.M.I. Electronics Ltd., Hayes, for the supply of an analogue numerical control equipment for a Cincinnati No. 3 milling machine. Bristol Aero-Engines Ltd. (B.A.E.) stated that their main objective in introducing a controlled machine tool into their plant, is a reduction in the production time by providing templates more quickly.

E.M.I. stated that in order to achieve the accuracy required, it would be necessary to fit leadscrews which are more accurate than those normally supplied and that the screws should have preloaded recirculating ball nuts.

E.M.I. made it clear to B.A.E. that the development was in the early stages, that detailed engineering was not yet complete and that the prototype which would fulfil the order could be expected to experience certain teething troubles. B.A.E. were prepared to take the equipment on these terms with the idea of evaluating the performance of, and the advantages to be gained from, the use of this method of machine tool control for the making of templates. B.A.E. very kindly offered to supply E.M.I. with periodic reports on the behaviour of the equipment and on the results obtained in making templates so that their experience could be made use of by E.M.I., in conjunction with their own experience, in improving the performance of production equipments.

The templates are of the two-dimensional type and two cuts, viz. a first and a finishing cut, were made on the controlled machine tool in each case. Many of the templates require to have internal square corners and some require to have dimensional

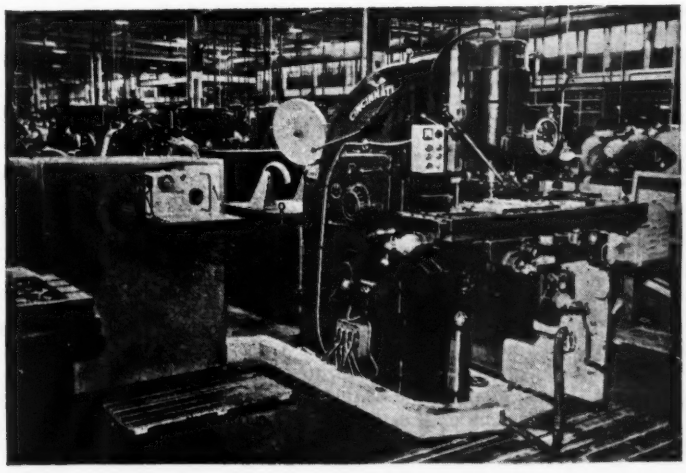


**Fig. 1. Prototype analogue machine tool equipment and Cincinnati No. 3 machine tool, referred to overleaf.**

accuracies which are of a higher order than is obtainable with the milling machine as modified and controlled. In the case where square internal corners are required, a further grinding operation is, of course, essential and the programme is then arranged to leave sufficient metal for this operation to be carried out. When the dimensional accuracy required is greater than the present leadscrews can provide, it is possible to measure the inaccuracy introduced by the leadscrews along their length, together with the backlash in each direction, and to make allowances for these errors when calculating programmes. In this way, provided that periodic measurements are made to detect changes in accuracy and backlash, the numerically-controlled machine tool can generate contours which are more accurate than a first consideration of the errors would suggest.

As a result of a period during which initial troubles were overcome and B.A.E. learnt how to do programming and to make tapes and use the equipment, which they did very quickly, followed by something over a year's further working experience, much has been done to iron out the initial difficulties. The equipment and the associated machine tool are shown, *in situ* at B.A.E., in Fig. 1.

## teething troubles

As was to be expected, difficulties arose, but these have been proved to be due almost entirely to unsatisfactory electrical components and to the leadscrews and nuts. Trouble has been experienced with the following components :-

relays ;
measuring potentiometers ;
rotary switches ;
motors.

### *relays*

The store relays must provide a low contact resistance. For this reason, hermetically-sealed relays of Ministry approved design were used, but early supplies of these still give considerable trouble. When fitted, before delivery to B.A.E., the percentage of rejects was unduly high and many have had to be replaced. Further work by the manufacturers has resulted in later samples being much better and those used in production equipment are initially free from trouble. In fact, the next equipment delivered, which contains 230 store relays, has been in use for 11 months and only four relays have had to be replaced. At the moment, the difficulty at B.A.E. is largely, though not completely, avoided by operating all the relays several times at the beginning of each week before the machine is used for cutting.

### *measuring potentiometers*

The measuring potentiometers proved to be insufficiently reliable and these have been replaced by variable linkage rotary transformers on later machines. Unfortunately, the change cannot be made on the B.A.E. machine, because it involves a major change which was not considered worthwhile.

**Table I**

| | | |
|---|---|---|
| TOTAL HOURS AVAILABLE ... ... | | 3,140 |
| Hours lost through lack of work ... | 175 | |
| Preparation for special exercises ... | 48 | |
| Hours lost for other reasons ... ... | 71 | |
| | 294 | |
| EFFECTIVE HOURS AVAILABLE ... | | 2,846 |
| Initial teething troubles ... ... | 228 | |
| Servicing time ... ... ... ... | 176 | |
| * Correcting vibration in milling machine | 82 | |
| * Leadscrew and ball nut adjustment ... | 88 | |
| | 574 | |
| | | 2,272 |

The actual use as a percentage of the effective available hours is 79.83%, neglecting errors shown in Table II.

* It should be noted that the 170 hours lost, representing 6% of the loss, are due to the machine tool and leadscrews and not to the control equipment. However, from the point of view of B.A.E., this must be included as lost time since B.A.E. were in no sense responsible.

**Table II**

**WORK DONE**

| *Period ending* | *No. made* | *No. faulty* | *% O.K.* |
|---|---|---|---|
| **1957** | | | |
| 6 February ... | 18 | 1 | 94.5 |
| 6 March ... | 21 | 3 | 85.7 |
| 13 April ... ... | 7 | 0 | 100.0 |
| 11 May ... ... | 15 | 6* | 60.0 (90.0) |
| 8 June ... ... | 16 | 2† | 87.5 |
| 6 July ... ... | 13 | 2 | 84.6 |
| 31 August ... | 10 (wedge) | 3‡ | 72.7 |
| 3 August ... | 17 (wedge) | 2‡ | 88.9 |
| 28 September ... | 24 | 3 | 87.5 |
| 26 October ... | 35 | 2 | 94.3 |
| 23 November ... | 10 | 0 | 100.0 |
| 21 December ... | 25 | 3 | 88.0 |
| **1958** | | | |
| 18 January ... | 2 | 0 | 100.0 |
| 15 February ... | 21 | 4 | 81.0 |
| 15 March ... | 17 | 4 | 76.5 |
| 12 April ... ... | 19 | 2 | 89.5 |

* The percentage of faults was abnormally high because work was continued although a fault was left uncorrected.
† One of these faults was traced to excessive backlash, which may also have contributed to earlier failures.
‡ The wedges (aerofoil shapes) do not provide an ideal use for the equipment. Nevertheless, they were satisfactorily made.

### *rotary switches*

Some faults were traced to dirty rotary switches. This type of switch was the result of extensive development work, and had been satisfactorily life-tested in connection with another application before being used in this equipment.

Preventive maintenance in the form of inspection and cleaning, when necessary, at three-monthly intervals is recommended; no trouble has been reported in connection with any other machine.

### *motors*

In order to achieve the performance required, the choice of servo motor appeared to lie between relatively small, high-speed, split-field, d.c. motors of a type designed for naval fire control work, a.c. motors operated from a 400 c/s sources, and hydraulic motors. The first type was chosen because of the extra equipment (motor-generators, pumps, etc.), and development work required for the others. These d.c. motors are, of course, subject to brush wear for which maintenance is required. There is a separate, but integrally constructed d.c. blower motor and if this fails for any reason, the servo motor may burn out. This has, in fact, happened and a device has been fitted to stop the machine if the trouble occurs. A separate a.c. blower motor can be much more reliable and has been used in production machines.

In order to obtain satisfactory finish on the type of steel which they normally use, B.A.E. have found it helpful to use a very low feed rate. In the equipment, as delivered, this involved running the interpolator motor so slowly that its speed was erratic and step-down gears were added to prevent this. In production equipments, a new type of motor is used in a redesigned assembly and a satisfactorily low creep rate is obtained together with a higher maximum speed.

## performance of the controlled machine tool

The general performance of the controlled machine tool is shown in the series of graphs (Figs 2 - 5) and Tables I and II. In considering these in detail it is necessary to draw attention to several facts, as follow :-

1. Except for a few special exercises, the equipment has been used only for making templates.
2. The specially fitted leadscrews and recirculating ball nuts made by another firm were also prototypes and they have proved to be subject to undue wear.
3. Although a considerable amount of available machine working time has been lost, some of this was due to causes which had no relation to the equipment or machine tool.

The graphs show the number of hours of use obtained from the controlled machine tool week by week over the whole period, plotted against available working hours. Full use in any week is, therefore, indicated by equal slopes for the possible and actual use curves.

No allowance is made for hours already lost in the possible use curve and, naturally, hours lost cannot possibly be regained. As would be expected, the utilisation factor is very poor at the beginning of the graph; the same thing occurs with any new and complex machine.

Table I shows the hours lost for various reasons, the losses being split into two sections of which the first (294 hours) may legitimately be considered as being due to causes for which the controlled machine tool is in no way to blame. By subtracting these from the possible use, or total hours available (3,140) the effective hours available (2,846) are deduced. The deduction of hours lost due to equipment or machine tool faults (574) gives the actual hours of use obtained (2,272). It will be seen that the actual use, quoted as a percentage, is 79.83 and this is considered to be reasonably good for a prototype machine embodying such novel features.

Full use, or partial use, in any week does not, however, mean that all the work done was satisfactory, so that the ratio just mentioned is, in fact, too high.

Table II shows the number of good and faulty templates made during the periods quoted, together with the percentage of good ones. It is, however, reasonable to eliminate five of the six faulty templates made during the week ending 11th May, 1957, since they were made when the equipment was known to be operating inaccurately. If this is done, the number of templates made becomes 10, the number faulty becomes one and the new percentage of good templates is then 90%. The good templates resulting from the work done in the whole period (February, 1957, to April, 1958) then amounts to 82.5%. Although this percentage would not be good enough for an up-to-date machine, it represents quite a reasonable achievement in the present circumstances. The rather wide variations in the weekly percentage indicate the peculiar nature of some of the machining faults; the system sometimes failed to perform correctly and corrected itself without the cause of failure being determined. The fact that the equipment is an early prototype doubtless contributed, in certain circumstances, to the difficulty of fault finding. In many cases, faults were due to high values of the stores relay contact resistance which, as already stated, were rectified merely by their operation a few times.

A much more serious fault was the continuously varying value of the backlash due to leadscrew and nut wear; this can ultimately be overcome only by replacing them with new ones of adequate hardness. Pickup also occurred, on one or two occasions, on the slides.

Another fault was the existence of vibration in the machine tool which resulted in undulations in the cut contours. This was corrected by the machine tool manufacturers, fairly early in the test programme, by balancing various parts and fitting some new bearings.

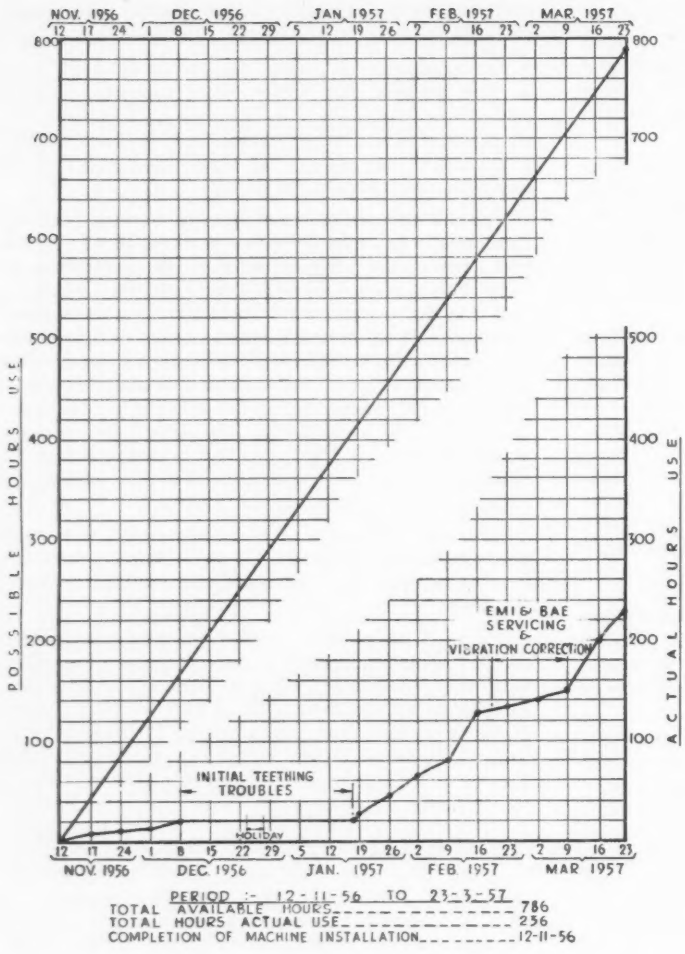



Fig. 2.

**exercises**

At one stage, it was decided to carry out some test exercises on the controlled machine. One of these consisted in cutting a circular groove. By measuring the degree of circularity, errors in the leadscrew and backlash errors may be detected over the range of motion used in cutting the circle, in the table position actually used. A further test consisted in cutting a wedge, of aerofoil shape with a vertical axis, from a block of metal approximately 6 in. cube. This is not an ideal use for the equipment since the cutter is necessarily rather long and, unless it is of considerable diameter, cutter deflection can be expected. In fact, satisfactory results were obtained.

**conclusions**

Mr. C. M. Tunstall, Assistant Works Manager, is of the opinion that the controlled machine, in spite of all the difficulties, has proved worthwhile in that it has enabled him to provide templates more quickly than before. Originally, the templates required three days to manufacture, while the average time now is five hours, not including programming and preparing the tape, but including machine setting-up time, cutting the templates and cleaning the machine. When a grinding operation is needed, this takes a further day. At the present time (May, 1958) templates are being produced with an accuracy of $\pm$ 0.002 in. as taken from the milling machine. In order to achieve this, backlash has been taken into account in making the programme, but leadscrew errors have not been included. Mr. Tunstall is quite convinced that the basic principles upon which the system is designed are completely sound and that a production equipment should do all that is claimed for it.

**acknowledgments**

The author would like to thank Bristol Aero-Engines Ltd. and E.M.I. Electronics Ltd. for permission to publish this short Paper. He would also like particularly to thank Mr. C. M. Tunstall, on his own behalf and on behalf of E.M.I., for his very great help in providing the data upon which this Paper is based and for all the care and attention which he has given to the performance tests. It would indeed be difficult to exaggerate the value of this work. The author's thanks are also due to Mr. W. H. Brownlow, of E.M.I., for much useful information gleaned from him as a result of his visits to Bristol to investigate the machine's behaviour; and to Messrs. R. H. Booth and S. C. Ansell, also of E.M.I.

*(illustrations continued overleaf)*

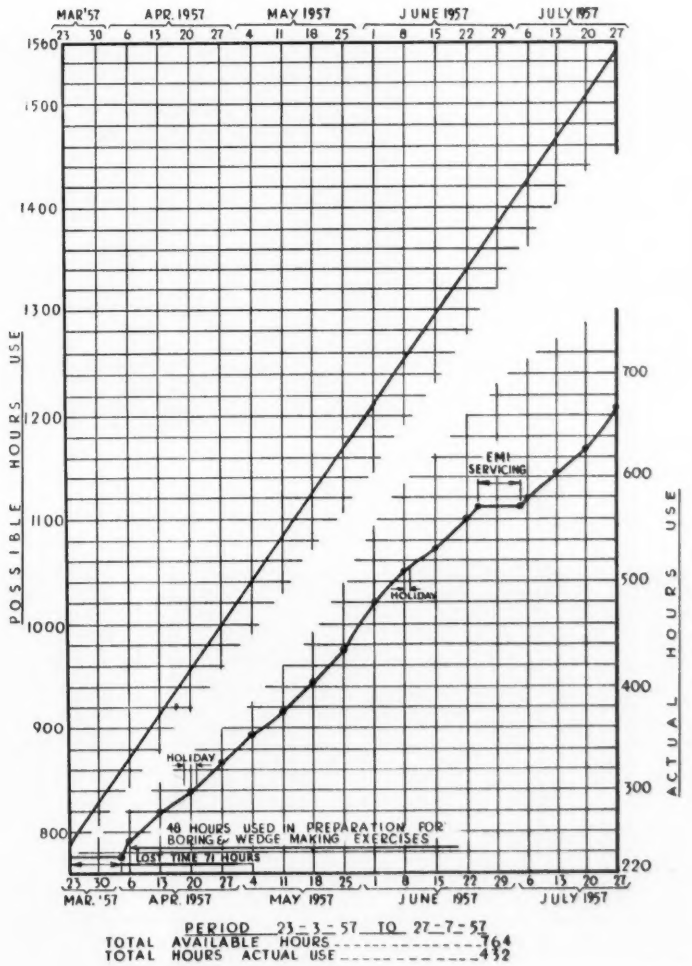



**Fig. 3.**

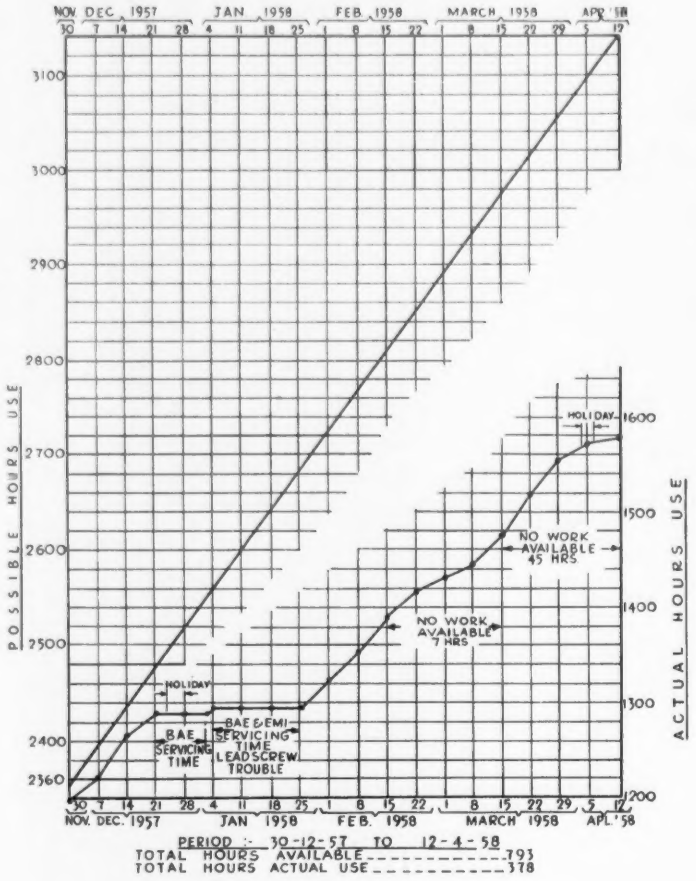

NOV DEC 1957
JAN 1958
FEB 1958
MARCH 1958
APL '58
POSSIBLE HOURS USE
ACTUAL HOURS USE
HOLIDAY
BAE SERVICING TIME
BAE & EMI SERVICING TIME
LEAD SCREW TROUBLE
NO WORK AVAILABLE 45 HRS
NO WORK AVAILABLE 7 HRS
PERIOD :- 30-12-57 TO 12-4-58
TOTAL HOURS AVAILABLE-----793
TOTAL HOURS ACTUAL USE-----378

Fig. 5.

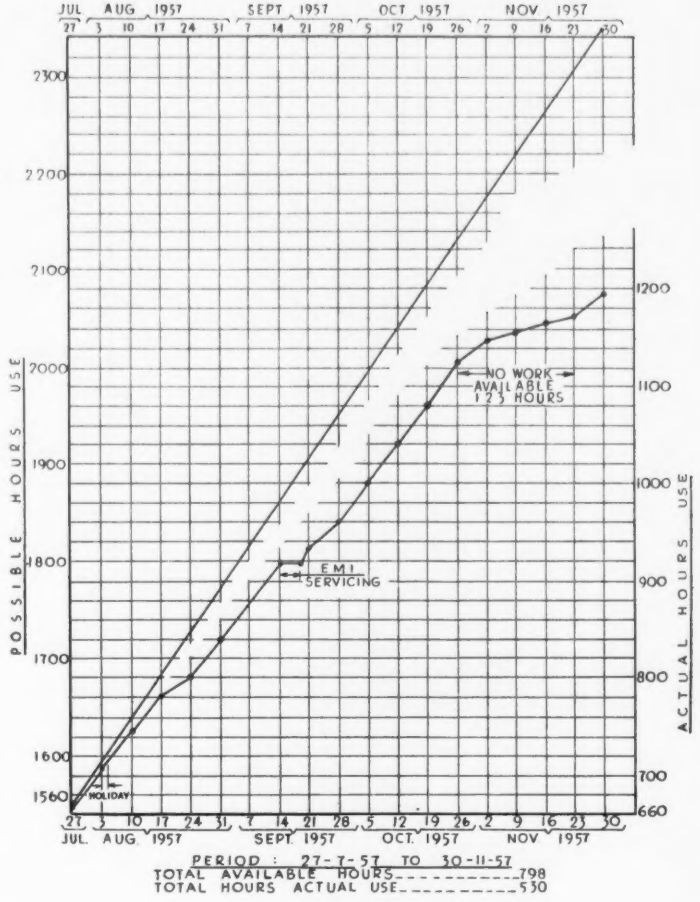
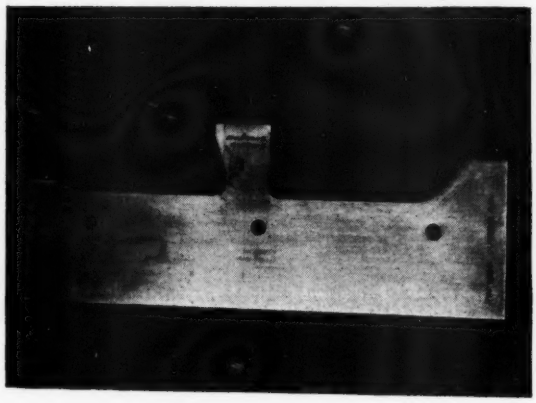
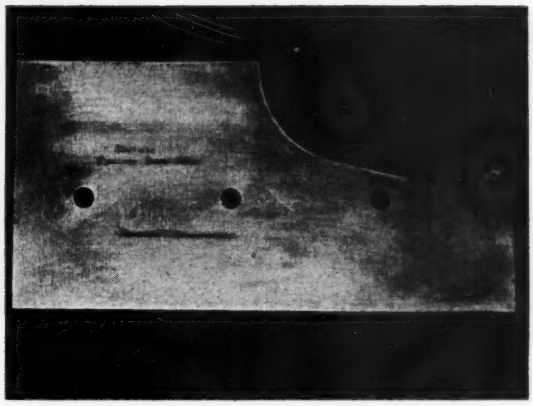
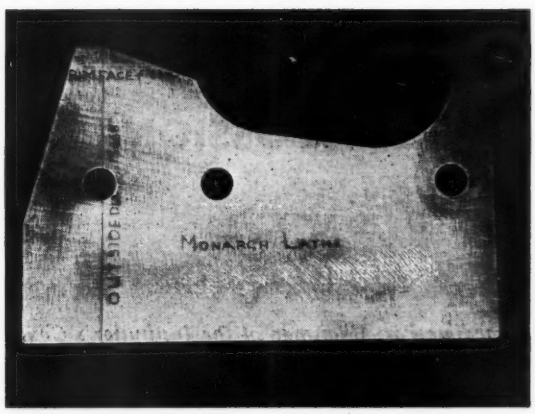

JUL AUG 1957
SEPT 1957
OCT 1957
NOV 1957
POSSIBLE HOURS USE
ACTUAL HOURS USE
HOLIDAY
EMI SERVICING
NO WORK AVAILABLE 123 HOURS
PERIOD : 27-7-57 TO 30-11-57
TOTAL AVAILABLE HOURS-----798
TOTAL HOURS ACTUAL USE-----530

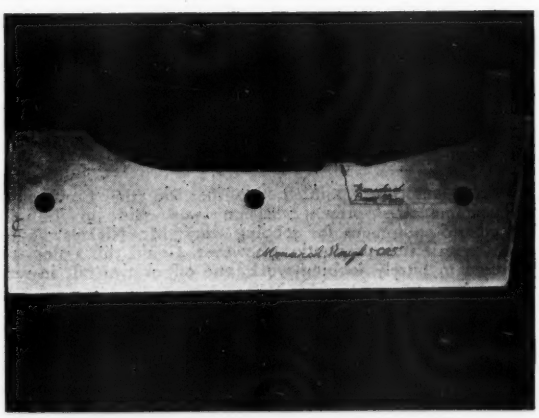
Fig. 4.

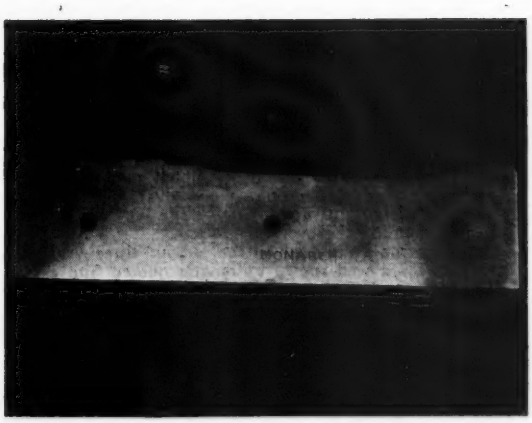
THE FOLLOWING PHOTOGRAPHS SHOW THE TEMPLATES REFERRED TO IN THE CASE STUDY

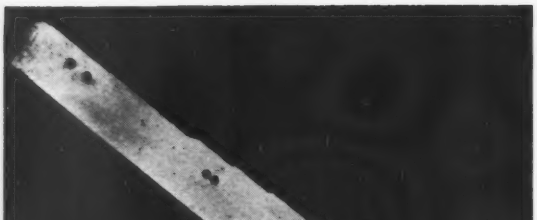










# DISCUSSION

Chairman:

**H. G. Gregory,** M.I.Prod.E.,

*Immediate Past Chairman of the Institution's Council.*

**Mr. Hollander** asked whether Mr. Nickols could give some indication of how the economic batch quantities might vary for a given part when produced by sequence control and, alternatively, on an ordinary automatic single spindle.

**Mr. Nickols** said he understood from a number of users that the setting up times appeared very clearly to be no more than 10 to 20 minutes over the time for setting up a conventional capstan. If one had a batch of these machines and they were a bit quiet for a few weeks, there was no reason why one of the machines standing idle could not be used as an ordinary capstan for making one or two off with a setter operator. From that point of view, there was versatility. In his personal experience of a very long run of several hundred thousand on a very difficult component, it was found that the times were completely competitive with single-spindle autos. Thus there were advantages from very small quantities right up to the stage at which multi-spindles began to take over.

There was one other advantage. About three years ago, the agents for a well-known automatic quoted him a cycle time of 50 seconds for a particular component. He was now, three years later, in complete agreement with this figure, having learned in the meantime a lot about special drills, reamers and cutting oils for the very difficult steel specified. Other firms that had tried to make the same component had originally cammed up to do it in this 50 second cycle time, but at least one of them had then made two other sets of cams for slower cycle times before even turning out any samples. On the other hand, the firm which was using sequence controlled automatic capstans two or three years ago got out components almost right away. They were not very profitable at first, as they were taking 3½ minutes each, but they were better than nothing and created goodwill while the tricks of machining this difficult material were being found out and the cycle time was being progressively reduced.

The very flexibility of the cycle meant that one could start with as slow or fast a speed as one liked. If there was excessive tool wear on one station, one could alter this individually. One could then use the machine as a sort of trial horse, before camming up conventional autos on long runs. There were certain advantages there.

**Mr. Macfarlane** pointed out that on the Conference programme the present Session was said to be on automatic equipment for jobbing work. Mr. Nickols' Paper dealt with batch production, however. Could this system be applied to purely jobbing work, one off or two off, in any way?

**Mr. Nickols** said he had every sympathy with Mr. Macfarlane. He had been given the title "Batch Production Automation", but if Mr. Macfarlane meant two or three components, there were obviously very few advantages because with a hand-operated capstan lathe, stops had to

be reset for every one, two or three components, and this also applied to automatic capstans. A number of jobbing firms had rather longer runs than two or three, however, and there was an advantage in that if there was suddenly a requirement for 30, exactly the same machine could be used automatically while the setter operator was doing a set up on another machine.

The cycle times would presumably be quite long for each of the two or three components the questioner might have in mind, and if this was 12 or 20 minutes or even longer there were definite savings simply because the cycle time was so long. After setting the first, one man only had to keep an eye on the machine and load blanks occasionally. An ordinary setter-operator type of man could thus be engaged in setting, most of the time dividing his attention between two machines.

The **Chairman** remarked that he thought 12 or 20 could be called a jobbing batch.

**Mr. Thompsett** asked how incentive schemes would apply.

**Mr. Nickols** said that one of the large motor firms he sometimes visited had changed over to a flat rate arrangement about 18 months ago. He had noticed whenever he went there that on the machine-controlled cycle operations they were now obviously very happy. But on welding with hand-operated jigs and operations of that kind where the individual's personal effort was the main thing, there would no doubt be definite improvements if an individual bonus scheme was still applied.

This did not get away from his own opinion that one of the primary aims was to get more and more machine-controlled cycles, even in quite short-run batch work. But one might well run into arguments and even disputes if the shop was in an awkward part of the country. If there was a "one man, one machine", idea in a certain part of the country, it might be possible eventually to change it. One or two famous firms had altered this old tradition in South Wales. But if one did not feel inclined to do that, there were other parts of the country and it might even, as a last resort, be necessary to move. Certainly automation for batch production could not exist if operators were going to count the number of machines in their care. What one must do is ensure that nobody does any manual work that could readily be avoided, however many machines might be looked after.

He had not quite answered the question, and he did not really intend to answer it. He felt that the obvious savings with this type of machine and this kind of approach were sufficient to justify its use. An entirely different motor manufacturer in Birmingham had told him that if any other firm in the Birmingham area got one of the Nickols machines, he would have one too. This kind of remark did not impress him tremendously, but the problem there was: "What are they (the unions) going to think of it?". To this he would reply that the machine was not very expensive. Put one somewhere in a corner and it would be up to the people concerned to find out what could be done with it. It had worked for him and for other people quite well for four years, and when the users realised its potentialities, they would find more and more applications for it in their own work.

The **Chairman** asked whether a flat rather than a piece-rate or bonus system would be the solution.

**Mr. Nickols** said the firms he had been most closely associated with seemed to have some form of group bonus or profit sharing scheme which worked very nicely. He had had no personal experience of administering a very hot piecework system and he was pleased that he had not.

**Mr. Perkins** asked how long it would take, approximately, fully to recover all expenditure by the revised methods before a saving could be shown. He referred particularly to the "certain representative components" quoted in the Paper.

**Mr. Nickols** said it was difficult to be impartial and not sound as if he were selling his wares on these occasions, but with a direct challenge of this kind he had no alternative. This equipment could be fitted within two days and if it was not working by the first night, it would be rather surprising. It would certainly be going the next morning. The installation people hung around for a little to make sure that the setters and planning engineers were happy. In the instance quoted at David Brown Ltd., the conversions cost £875 each and the machines were installed just before Christmas, because they were not available before that. The schedule was dated 28th March, so the savings illustrated were effected before then. Obviously, the setting times were longer at first, particularly as there was a night shift and about six setters were concerned in the initial training. But he was agreeably surprised to be shown such good figures so soon, and it looked as though the cost of the conversion would be saved in little more than six or seven months — certainly less than a year.

**Mr. Macfarlane** said he presumed Mr. Udal hoped one could work towards completely automatic equipment. Was he satisfied with having a man there? The fact that he had to stand there with his feet on the bottom must be a disadvantage in some way. One could easily put a brake on the pedal or an electronic device to see that not more than one piece was fed in and that it did not jump out and so dispense with a lot of men, and not have them in a long chain as this particular firm did.

**Mr. Udal** said that this was a real point. The typical parts he had in mind were pressings, such as motor car door panels. They were big and hefty and difficult to stack, and it would probably take the operator all his time to put them into a loading station from which they could be transferred automatically into the machine.

To speak now in practical terms, for the machine on display they had borrowed some discs and hand-loaded them on to a loader. From the loader they went into the press and out at the back. It would be easy to make that automatic in a plant and to arrange a pick-up feed for the discs which were nice round objects, easy to handle, with no angular locations. But the number of jobs of that nature in the average press shop was in a minority. Most jobs were more complicated and most shapes were more awkward.

It was certainly a good idea to aim at a completely automatic arrangement and in suitable cases there was nothing to stop it, but if one considered the firm processing the discs, their labour costs had been halved while their production had been doubled, and they were, therefore, pretty happy.

**Mr. Macfarlane** asked whether magnetic attachments could be used instead of a mechanical device if the objects were angular. They were presumably of mild steel.

**Mr. Udal** replied that electromagentic pick-ups could be used. More popular was the suction pad with a vacuum motor. One disadvantage with magnetic pick-ups was the struggle to come off the tool. Some of the magnetic flux went through the job and on to the tool. It could be done, but one had to be careful to locate the magnet so that it did not make a solid contact, and caused the job to move up on to the magnet by getting a little lift through an air gap. Tricky height control was needed, but it definitely had a field of use. With an electromagnetic coil, it was possible to turn on and off as one wanted to pick up and release.

**Mr. Belsher** drew attention to the statement that guards did not cause any appreciable slowing down of the speed of operation of the components. He thought this would depend very much on the type of component that was being loaded, and on the operators themselves. Frankly, many operators were scared. He believed the use of photo-electric cell guards with an adequate brake on the press had been suggested and that they were, indeed, being used in Germany at the moment. Could Mr. Udal tell him anything about that?

**Mr. Udal** said this was a bit outside the main line, and he was, of course, in some difficulty in discussing this completely without bias, but he would do his best.

It was true that considerable use was made of photo-electric cell safety equipment on the Continent. It might have something to do with the very large number of accidents there as compared with the U.K.: he himself thought that it had. Without going into detail, he thought this was the reason. The photo-cell equipment controlled the controls of the machine, so as long as the machine was responsive to its controls and assuming the photo-cell stuff was all right, there would be a safe system of working. As soon as the machine ceased to respond properly to its own control system, there was no guarding system. This was the difference between the type of guard demanded on the Continent and in this country. When they had an accident on the Continent, they said it was an act of God, but the Factory Department here would not accept the Deity as responsible: they demanded something different.

His firm had done some guarding for Continental users of presses and he had in mind one of the big firms making motor car body pressings. They said that apart from cutting down on the accidents they used to have whenever the press clutch failed to disengage, as it could, or the slide should fail to be held, as it should be, they were doing more production with the guards than they had done with photo-cells.

He agreed about operators being scared, but they should be trained not to be.

**Mr. Beer** asked why the unloader should not stack the parts in a suitable position where there was a line.

**Mr. Udal** said there was no basic reason. In fact, unloaders had been made to unload planks and stack them very satisfactorily with a little guiding.

He had in mind a job where chassis frame side members were stacked very well. It was a question of what was wanted. Normally in this country, with a completely automatic line, one was not interested in accurate stacking but in dropping on to a conveyor. This could be done without accuracy of a few thou, which would be necessary in stacking from the unloader in the case of some components. If this was wanted, it could be provided. Generally speaking, it was not wanted, and it would be fairly expensive. Accuracy would be required at both ends of the traverse instead of at one end only, and that cost money.

**Mr. Pashley** asked Mr. Puckle what kind of templates were made, what was the material, and what type of cutters were used in the milling machine?

**Mr. Puckle** said he did not know the answer because they were templates used in connection with aircraft jobs. Many of them were secret, but those illustrated in the Paper were not secret. They were of various sizes.

Mr. Brownlow, who was a representative of the installation branch of the Company, had spent some time at Bristol and he could probably answer questions of this kind.

The **Chairman** said they looked like the straightforward templates one would put on a forming lathe, plate type.

**Mr. Brownlow** said they were normally cut in gauge plate and the cutters were normally $\frac{1}{4}$ in.

**Mr. Macfarlane** confirmed from Mr. Puckle that this was really jobbing work, and that only one of these templates was made at a time. It was really automatic equipment for jobbing work.

In agreeing to the latter point, **Mr. Puckle** said the application would probably be better appreciated if it was remembered that the machine was in a development stage.

**Mr. Macfarlane** asked whether the apparatus could be applied to making anything on a small scale, a small number using this kind of equipment.

**Mr. Puckle** said that that was perfectly true. He would like to point out that the equipment could be fitted to all sorts of different machine tools. The numbers off depended very much on circumstances. For example, it was being applied to table positioning machines, to rotary tables, to milling machines, both hydraulic and motor operated, and also to large skin milling machines which might go up to 40 ft. or 50 ft. long and 12 ft. wide. Wings, for instance, might be small in number. This was a production job, although the production quantities would be small.

When smaller things were made on a smaller machine, it did not in his opinion pay to use it for production quantities. It was better to use the machine to make a template and then use a template machine for making the large quantities.

On the other hand, in Australia, where the rates of pay were extremely high, they were considering using this machine actually on the shop floor for some production jobs.

It was his own personal feeling that the flexibility of this type of machine was not best exploited if used in that way.

One case where it was possibly useful for production was where the material out of which the parts were being made was extremely expensive, so that damage done by human error could be very costly.

**Mr. Macfarlane** said he had in mind one or two off where the design changed every time an order came in.

He was thinking of the use of this method for facings and drillings and so on, on valuable castings, where one would not get the error a man would probably put in. Was he right in thinking it could be used in such cases?

**Mr. Puckle** said he was absolutely right. This was the best way to use it. It was extremely valuable, in developing a piece of machinery, to make some of the components in this way. One could make a component to a certain design. If it proved not to be just what one wanted, it could be modified very quickly. The part could be obtained in a matter of hours instead of days or weeks. Therefore, the engineers on development did not have that horrible frustrating feeling they got when they had to wait for weeks before a new part became available.

There was also the advantage that the engineer who was developing something would not say: "All right. I'll try to get this put right in production. We can't wait. We shall have to use it as it is." He could get the thing right before attempting to produce it. This was of very great value.

**Mr. King** asked whether the problems and troubles had now been sorted out and whether it was now possible to work efficiently.

**Mr. Puckle** said the position was a great deal better, but he would not go so far as to say it was perfect. No one was ever satisfied, in any case, and it was quite right that they should not be.

**Mr. Millyard** said he noticed from the preprint that the templates used to take about three days to manufacture, whereas now they took an average time of five hours, including the setting-up time. How long was the programming? What proportion of the time was required?

**Mr. Puckle** said it depended very much indeed on the actual shape of the template. He could not specify the exact time, but he could make a guess as to the time that ought to be taken. It would perhaps vary from three to six hours. However, the important thing was that the machine tool could be doing a useful job while a programme was being prepared for another part.

**Mr. Brooks** said that equipment would presumably have to be replaced from time to time. Was the cost likely to be high or low? He was thinking of valves, and so on.

**Mr. Puckle** said the cost should be very low. He could not say what it would be, because he did not know, but there were very few valves. It was nearly all motors, switches, relays and transformers. It was an advantage that these were all things with which the ordinary works maintenance engineer was quite familiar — though possibly not with relays and uniselectors. But it was within his ability to understand them very quickly and it was very easy to teach him. A large number of works maintenance engineers were completely unfamiliar with valves. However, as he had said, there were very few of them. There were one or two in the amplifier and the rectifier system, but this was a small matter.

He did not think the speaker need worry about this: certainly he could be provided with information if he would write for it. In any case, the instruction book supplied with the control system gave information on maintenance and fault-finding.

**Mr. Rider** asked Mr. Puckle roughly how many of these equipments he had in various factories. Of those which were out in use, in how many instances were the works maintenance people themselves able to maintain them, or how frequently did Mr. Puckle's firm or some other firm have to go round to maintain good order ?

**Mr. Puckle** said it depended on where the machine was, how long the factory had had it, and so on. When the machine was first installed, someone was sent along to make sure it was understood. They stayed until they were satisfied that there was little chance of any difficulty arising.

No machine could be made in such a way that it would never break down. One did the best one could to make it as good as possible, to make it as safe as possible and to make it easily serviced. This was about as far as one could possibly go.

After that, having taught the maintenance people at the works, one had to leave it to them. Mr. Brownlow might be able to give further details.

**Mr. Brownlow** said that ordinarily six months' free service was given with these machines once they were installed. Normally the installation was visited at three-monthly intervals, which meant two further visits after the initial installation. Further visits were the subject of a contract. If the customer still required a personal interest to be taken in his machine, the contract was arranged accordingly. Otherwise, his own maintenance staff could look after it. If he was really in trouble he rang up and everything possible was done to assist him.

The machines out in the field were running very well and apart from one or two incidents the firm were having a fairly easy time on maintenance.

**Mr. Rider** said he had not intended to suggest that the equipment was not satisfactory, but normally the engineer regarded electronics as an unknown " bag of tricks ". With a machine of this kind on their premises, did they look after it and were they sufficiently happy and able to look after it without difficulty ?

**Mr. Brownlow** said there was very little electronics in it. It was electromagentic for the most part. The amplifier and the power unit were the only electronic parts.

**Mr. Warner** asked Mr. Puckle whether any tape control units would be available which would be economical on ordinary smallish production batches of 50 or 100 off on milling or drilling machines. He had said that his unit could be used mainly for making equipment to produce batches, but not to produce the batches themselves.

**Mr. Puckle** said he had perhaps not made himself clear. In saying it was not advisable to use the unit for production, he meant certainly not for production of the order of hundreds or thousands or tens of thousands. There was no reason why it should not be used for small production runs.

Its extreme value lay in its flexibility. It could be made to do many jobs very quickly indeed, and it was not necessarily most economical to use it for quantities, but there was no reason why one should not do so if one wished.

Once the tape was made, the parts came rolling off very much more quickly than by any other method. There was not the human error and a tremendous amount of time and money was saved.

Furthermore, if material cut proved to be faulty or if material became damaged in a later operation, the cost of replacing the part was very much less because the labour cost was reduced.

**Mr. Warner** said he was actually thinking of production which required batches of 50, say, four times a year. For this, he would have thought the equipment rather suitable.

**Mr. Puckle** said that it would be particularly useful in such a case. For example, one could put aside the tape and give it a part number. When it was wanted, it could be introduced into another schedule of work without wasting much time. All that would be required would be to change the bolster cutting tool and the workpiece and put in the tape. There was no messing about while the man tried to understand what he was required to make and determined the best way in which to do it, and to make the necessary measurements and so on. The tape machine went straight ahead. The utilisation factor of a controlled machine tool was very much greater than that of an ordinary one.

**Mr. Daniels** asked what capital cost was involved in equipping, say, a milling machine.

**Mr. Puckle** replied that it depended entirely on whether extra facilities were wanted or not. The price of the ordinary straightforward equipment without a lot of extras was of the order of £8,000, and that did not take very long to get back again, because the amount of work that could be produced with it was very great indeed.

Perhaps he might put it in this way. The time saving that could be made was so great that on the first part made from the tape, including the time for making the tape, the saving could vary from about 60% to 90%. That was the saving in time as compared with ordinary manual control of the milling machine.

With the second or further parts it was fairly reasonable to exclude the time required for making the tape. In that case the saving in time could be from 80% to 98% for each part.

Once the tape was made, the first and subsequent parts could be made at the rate of 5 to 25 parts in the same time as it would take to make another one by ordinary hand operation of the milling machine.

**Mr. Nicholas** said he understood Mr. Nickols inspected and checked and sampled as he went along to see if the machine was running and adjusting by quantity control methods. In Mr. Puckle's case, what did he do about inspection to check the machine ? If he was only doing one off he had to do a 100% check to see if the machine had gone off in any dimension. Did he sample ?

**Mr. Puckle** said there were two possible faults. First there was a fault in the production of the tape. Secondly, the information on the tape, like the information on the drawing, was only accurate to whatever limit one happened to put on it.

After the first part was made, the best thing to do was first of all to glance at it and see that nothing had obviously gone wrong. In other words, there might be a huge hole in it owing to someone having put down a wrong dimension. This was extremely unlikely but it might happen in the first few parts, because the programmer and the maker of the tape had to have a little practice.

It might be that there was no need to make a check after the first part. It might be found after considerable experience on the part of the programmer, the person who punched

the tape and the man who used the machine and so on that there was no need to check, particularly if the limit to which the part was made was not a very small one. It was naturally of interest to see that for very fine limits the machine was run more slowly, just as in ordinary work. For fine limits and finish one could make a second cut which did not take much time and, since so much time was saved by the use of numerical control, the time spent in making the second cut still left a very handsome saving.

**Mr. Gulteridge** asked whether the templates made on the E.M.I. machine at Bristol worked out much cheaper than those made by hand methods. It had been said that the machine time was only five hours and the manufacture of the tape and the programming took between three and six hours. The time by hand methods was about three days. Presumably if the machine cost £8,000 there would be a much higher overhead rate on the machine. What were the relative costs ?

**Mr. Puckle** said this was certainly an important question, but he did not know the answer. The main point was that the templates could be obtained very much more quickly and it was not necessary to wait a long time for them. This must obviously save money. Presumably it would allow the £8,000 to be cancelled in perhaps a year or conceivably two years. Taking this and the overheads into account, it would not be difficult to work out.

He did not think there was any doubt that the saving would be considerable, taking into account the time required and the cost of the labour. This need not be as skilful as the labour needed to operate the machine by manual methods. The fact that the original cost could be written off in a relatively short period surely spoke for the fact that the cost of the template must be considerably less than when made by ordinary manual methods.

Referring to the rate per hour, the **Chairman** said the normal rate might be £4 10s. 0d.

**Mr. Puckle** said that cost per hour of running a controlled machine tool depended on many different factors, but on the other hand if one could manage something like 20 parts in the time to do one ordinarily, one could not avoid making a little money.

**Mr. Burgess** asked whether Mr. Udal was really serious in saying the adoption of guards on press working did not increase the cycle time. He had every sympathy with him, but in 9 cases out of 10 there was an increase in cycle time.

There was another point which was not strictly relevant. Some time ago there had been some recommendations, with which Mr. Udal was associated, about press working and the safety of the press and the adoption of braking action on the stroke of a press. Was it possible to inch off the stroke of a press at any point after its cycle and how was it done ?

**Mr. Udal** said these were two entirely different points. As to the first one, he was being serious, but serious with limitations. If the only consideration was production and the operator was set to work without any kind of impediment whatever, he would work faster without a guard than with one, but being human he would have an accident fairly soon.

The kind of guard commonly used in the U.K. gave as good production rates or better rates than the steps taken to provide some kind of reasonable operator safety elsewhere — in the United States and on the Continent.

The most general scheme in the United States was to use two push-buttons or levers to occupy both hands. The time taken to move, and the effort required to move from a loading position thousands of times a day, had a bigger slowing-down effect than the use of the equipment provided in this country on most components. He was, of course, generalising a bit. One might find odd jobs where the two-button arrangement was better. But by and large it was not better from the production point of view but quite a lot slower.

He had come across a case recently where on pneumatic presses an arrangement of two hand valves in sequence had been discarded in favour of a shutter guard. The last fraction of the closing guard operated a valve which brought down a ram. This was a little faster and less fatiguing than using two hands.

As to holding up a power press during the course of its stroke, this was difficult, if it could only be done by brutal methods. It could, however, be accomplished as by one of the British makers, Taylor and Challen, by an intensifying brake on their presses which would bring the crankshaft and flywheel to rest in about 40° rotation of the crankshaft, if necessary.

His own company had a similar apparatus. One had to use 30° rotation to bring the flywheel to rest, and even then it was a violent process. The energy of motion in the flywheel had to be turned into heat through a brake, and the element of violence came in because this had to be done quickly but, nevertheless, the necessary heat could be developed in the brake to bring the flywheel to rest in 30° or 40° rotation without excessive strain or load on the crankshaft clutch key, and so on.

In a further comment, **Mr. Burgess** said that no one liked the appearance of the fly press: it was old-fashioned. So they paid more and installed a pneumatic or hydraulic press where there was a shutter guard or dead man valve, and there was evidence that when this equipment was installed, the piecework price would go up 50%.

**Mr. Udal** said it was very hard to deal with a specific criticism in general terms. He was prepared to believe it would operate in certain cases. He had a mental picture of middle-aged ladies doing an operation splitting pen nibs on hand presses. They did about 100,000 a week, one at a time. The trouble was that there was a row of people described by the works management as "girls" — the youngest was about 50 — and there was no one to take their place. Something different would have to be done. That sort of mechanical slavery the young ones would not tolerate.

He was quite sure one would never get any guard arrangement to give the same production in that particular case. He had no doubt the speaker had something similar in mind and was in much the same boat.

The **Chairman** said he thought it would be agreed that it was very difficult to replace the ordinary fly press operated by someone who was prepared to work it. Other means had to be found and it was very difficult to get the same efficiency with certain operations.

**Mr. Udal** agreed with **Mr. Burgess** that it was mechanical slavery to employ an operator to load the press mechanically.

As to whether something should be done about it, **Mr. Udal** said it was still mechanical slavery to employ an operator to keep on feeding into a stack. There were a number of suggestions. There was *Brave New World* where a "delta" type was created, the kind of man who would do that kind of job and be happy. In the present circumstances, there was no ideal answer.

**Mr. Burgess** said he mentioned it because he had recently paid a visit to the United States where he had seen about 50 firms. He was appalled to see the number of cases where the loading of the machine was done mechanically, but the loading of the transfer device was done by hand. It seemed to be a comparatively simple matter to make the whole thing automatic and it should be done.

**Mr. Udal** said he had seen exactly the same thing. Operators were chained to the wheel with no time to do anything but go through the rhythm. There must be a fairly good reason for keeping them on the job. They acted as human monitors. They were there to stop things if anything went wrong. It was not only the feed mechanism that could go wrong. There could be a piece of metal which was not loaded properly and stuck in the tool. One had to stop

quickly. A photo-electric cell could be used as a monitoring device or use could be made of gamma-ray detectors. Mr. Puckle had referred to relays, and they sometimes went wrong. That was why the operator was there. He had asked about this in the States particularly, because their quantities were bigger than in this country and there was more incentive to be completely automatic. The answer given was that if one had to have an operator for monitoring purposes, one might as well make him work physically, and that this tended to maintain his mental alertness.

**Mr. Belsher** asked Mr. Nickols whether he had experimented on his particular device with a cheap form of transfer feed that could be adapted to a line of drilling machines.

**Mr. Nickols** said that sequence control was perfectly applicable to any form of transfer and feed arrangements for drilling machines, although in fact with most of the devices which came under the category of rotary indexing or transfer machines, he usually found the sequence relatively simple. It is often only in three stages — the "shunt", the "clamp", and then all the heads start feeding in together. They each retract individually when they have finished their strokes, and a line of micro switches in series signals when they are all clear for the "shunt" to begin again. There are thus only three main steps and usually ordinary relays in cascade are quite satisfactory for this purpose; but where there are complicated sequences with more than three steps, and automatic loading devices have to be programmed as well, the advantages of sequence control become increasingly pronounced.

The **Chairman** said that the case studies presented had given much food for thought. Many people knew the answers before they asked the questions, but there was no question that with batch production there was a field for loaders and a field for automatic capstans and a field in what Mr. Puckle had described as being the control of the No. 3 Cincinnati.

The Chairman did not propose to try to collect all these things together, because they were in different fields of activity. Nevertheless, there was a basic understanding of, and desire to make and use, modern developments, both electronic and hydraulic, in order to increase further production for small batches.

It was his personal view — and he had said this in print and elsewhere — that electronically controlled machine tools, whether tape control or punched card control or what have you, would come more into their daily lives and fields of industrial experience within a very short time.

They must also feel, he thought, that Mr. Puckle's Paper was particularly valuable because he had explained the snags experienced in the development of this machine at B.A.E. It was not often that lecturers were prepared to discuss the difficulties encountered in this way.

On behalf of the Institution, the Chairman thanked the speakers for the trouble they had taken in preparing their Papers and for the frank way they had dealt with questions raised in the discussion. Some extremely interesting information had come to light as a result.

*The proceedings then terminated.*

# DIARY DATES

**DECEMBER 11th**

**The 1958 Sir Alfred Herbert Paper,** to be presented at the Royal Institution, London.

Speaker : **Sir Cecil Weir,** Past President of the Institution.

Subject : **"The European Common Market — Its Origins and Implications".**

## 1959

**MARCH 11th**

**The 1958 Viscount Nuffield Paper,** to be presented at the University of Birmingham.

Speaker : **Dr. N. P. Inglis,** Metals Division Research Director, I.C.I. Ltd.

Subject : **"The Production, Fabrication, Properties and Uses of Some of the Newer Metals".**

# the application of

# SPARK EROSION MACHINING

*a Paper presented to the London Graduate Section of the Institution, on 1st April, 1958*

*by* **A. J. LAWRANCE,**
**G.I.Mech.E., Grad.I.Prod.E.**

*Mr. Lawrance was educated at Balgowan Secondary School, Beckenham, Kent, and served his apprenticeship with Sure-Tools Ltd., trade toolmakers. He attended Croydon Polytechnic, gaining Ordinary and Higher National Certificates, and passing the Associate Membership Examination of The Institution of Mechanical Engineers.*

*In 1945, he was appointed Chief Tool Designer to Sure-Tools Ltd., and the following year took up the appointment of Managing Director of Batco Tools Ltd.*

*When this firm amalgamated with B. Kimber, Allen & Company, manufacturing electrical engineers, in 1957, Mr. Lawrance was appointed Works Director of the new Company, Kimber-Allen Ltd.*

BRITISH industry is frequently accused of being slow to apply new scientific developments. This, however, is certainly not true of spark erosion machining, largely due to the efforts of one company, who, having obtained a patent in 1950, quickly developed and produced a sound, practical machine which has almost revolutionised, or at least broadened, the horizon of many sections of industry. Nevertheless, as with all processes, spark erosion machining has its limitations, and cannot be regarded as a universal panacea for curing all machining problems.

Machines for the removal of metal by spark erosion have been available in this country for the past five years and since their introduction a number of excellent Papers dealing with the theory and development of the process have been published, the most notable of these being "Principles and Applications of Spark Machining" by D. W. Rudorff [1] and a translation from a Russian Paper "Working Metals by Electro-Sparking" by A. V. Nosov and D. V. Bykov [2]. It is not, therefore, the purpose of the present Paper to expound the theory and development of the process, as this ground has been adequately covered by those far better qualified to do so, but to try to illustrate, by examples drawn from the results of three years' operation of one of these machines, exactly what are the advantages and limitations of the process, and to extract from this experience the fundamentals of a new technique, namely, the application of spark erosion machining.

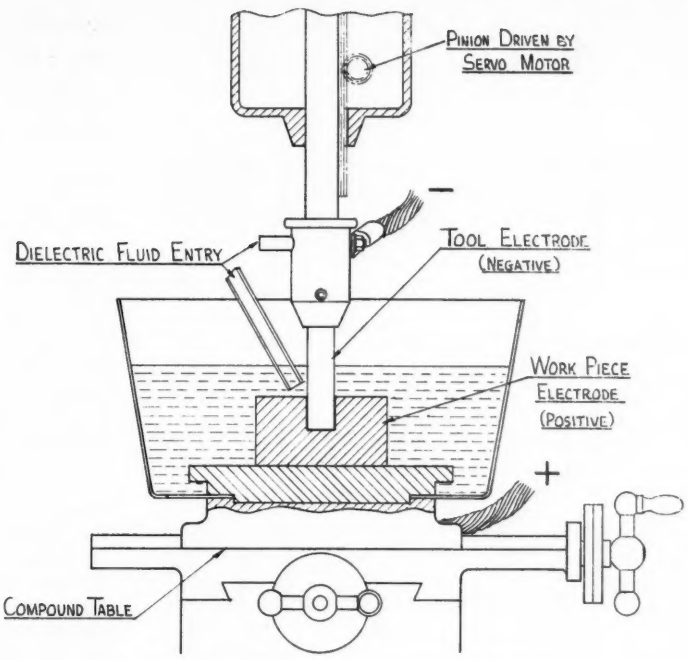



**Fig. 1.** — GENERAL ARRANGEMENT OF SPARK EROSION MACHINE —

**process**

The removal of metal by spark erosion is accomplished by a series of momentarily heavy electrical discharges across a gap between two electrodes immersed in a dielectric fluid. Electric breakdown of the fluid leads to the formation of a spark which produces localised melting and partial evaporation of the surface metal, thus producing erosion of both electrodes. As this discharge will only take place when the gap between the electrodes reaches a critical value, means must be provided to maintain the relationship between the two electrodes so that discharges take place continuously.

Fig. 1 shows a typical practical arrangement of a spark erosion machine, in which the positive electrode becomes the workpiece and the negative electrode is the cutting tool. This polarity is used because, in a spark discharge across two electrodes of the same material, the positive electrode is eroded at a greater rate than the negative electrode.

Both cutting electrode and workpiece are immersed in a tank of dielectric fluid, normally paraffin or a paraffin-napthanic oil mixture, the workpiece being clamped to a stationary adjustable table and the cutting electrode mounted in a chuck on a vertical slide controlled by a servo mechanism, in this case an electric servo motor coupled through a reduction gearbox to a pinion engaged in a rack on the vertical slide, which feeds the cutting electrode to maintain a constant spark gap. On supplying current through the electrodes, discharges take place, the cutting electrode and workpiece are eroded, the gap is increased and by measurement of the consequent voltage drop, the feedback control system energises the servo mechanism which feeds the cutting electrode forward until the gap again reaches its critical value, and sparking once more takes place. This process is continuous and, once the machine controls have been set, will continue automatically without further attention from the operator until a predetermined depth setting has been reached. Controls are provided on the machine by which the current density may be varied. The current density governs the rate of cutting, the spark gap between the cutting electrode and the workpiece and the finish produced on the workpiece. The values of each of the above factors will vary according to the material being machined and to a lesser extent with the electrode material but generally, the higher the current density, the faster the cutting rate, the wider the spark gap and the coarser the finish.

When using low current densities for finishing cuts to produce the best surface finish, the balance of the servo control becomes extremely delicate and settings are liable to be upset by outside influences such as the eroded sludge and the gaseous products of the dielectric breakdown becoming trapped beneath the cutting electrode, for example, when machining deep, blind holes. To assist in overcoming this difficulty, the dielectric fluid is also used as a circulator and

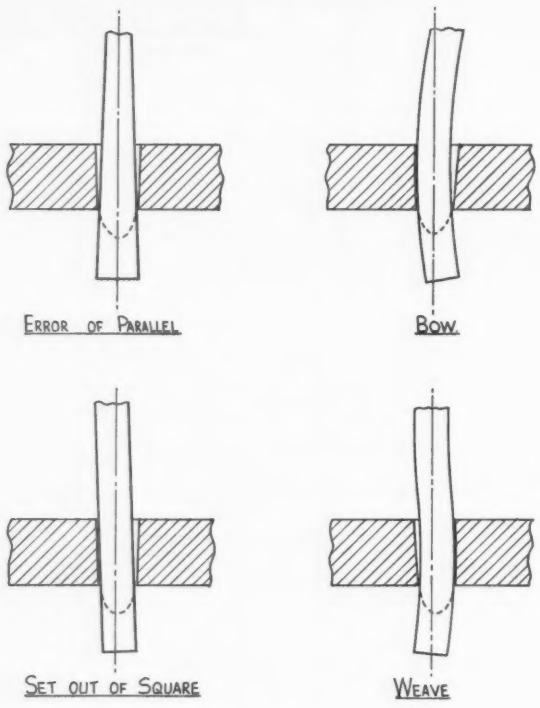



**Fig. 2.**

flushing agent, machines being equipped with a pump and storage tank unit and a flexible delivery hose that may be positioned to agitate the fluid in the cutting area, or may be attached to the chuck of the machine to inject fluid through a hollow electrode. The storage tank is also used to settle out the eroded sludge by a system of weirs, baffles and filters.

Although special purpose machines have been built to move the cutting electrode through a curved or spiral path, normally the electrode moves in a vertical path only. Thus the process is applicable to the machining of through holes of any profile for which an electrode of the desired cross section can be made, and to the machining of three-dimensional cavities of any shape that can be eroded by moving a complementary male form through a vertical path.

All materials capable of passing an electric current are machinable by spark erosion, the ease of machining depending only on their electrical properties and being entirely independent of mechanical characteristics such as hardness. Thus steels may be readily machined in the hardened condition to avoid the danger of subsequent distortion and hard materials, such as tungsten carbide, which can only be worked with difficulty by normal machining processes, present no difficulty to spark erosion machining; indeed, generally, the harder the material the better the surface finish produced.

## application and accuracy

### *advantages and limitations*

The field of application for spark erosion machining may be divided into three broad groups although on some occasions, these groups overlap.

*Group* 1. Use in the toolroom for the modification, correction or repair of moulds, dies and tools which have been hardened. For example, modifications may be made to tools already in service without the need for annealing with its attendant dangers and, indeed, without even disturbing the surface finish except where machining takes place. Salvage operations may be carried out on tool parts and, where justified, on production parts. These include the removal of broken drills and taps, modifications or corrections to parts already hardened and ground, and the machining out of broken or damaged sections to receive inserts.

*Group* 2. Use in the toolroom for work on moulds, dies and tools which could be accomplished by normal machining or hand fitting methods but which can be accomplished more economically by spark erosion machining. For example, it may be possible to avoid making a split die solely to facilitate manufacture of the tool, thus showing great saving especially where tools are required for relatively short runs.

*Group* 3. Use in the toolroom, or in production, for the machining of parts specifically designed for machining by spark erosion. Thus the designer is no longer restricted by machining difficulties on hard metals, by limitations of conventional machines or machining processes or by the need to fabricate parts to facilitate manufacture.

Most engineers have at some time come up against the so-called " draughtsman's dream ", in which the ideal requirement is virtually impossible to machine. Spark erosion machining may make his dream come true.

The spark erosion process is basically a copying process and the accuracy obtainable will, therefore, depend primarily on the accuracy of the electrode. The control of the machine ensures that, under identical conditions, identical results will be obtained and, therefore, work produced will be as accurate as the electrode used to produce it. Conversely, no matter how accurate the slides, lead-screws and other physical elements of the machine, the work produced can never be more accurate than the electrode used to machine it.

The main limitation to electrode accuracy is the relatively high rate at which the cutting electrode is itself eroded while eroding the workpiece. The ratio of metal loss from the cutting electrode to metal removal from the workpiece, commonly known as the erosion factor, may be as high as 3 : 1 by volume or even higher by length if the electrode has a small cross-sectional area of local thin sections. When machining hardened carbon steels using brass electrodes, the erosion factor by volume will be found

to be in the order of 1, brass with brass 0.5, tungsten carbide with brass 3. Also, due to non-uniform field distribution across the electrode section, the rate of wear increases at the outer faces of the electrode. A cylindrical, flat-faced electrode will be found to have eroded to a tapered, bullet-nose shape after machining a through hole. Thus, to produce parallel holes, extra length must be added to the electrode to allow the tapered section to pass right through. A suitable electrode length for machining parallel through holes may be determined from the expression : L × EF + 2L where L is the length of hole to be machined and EF is the erosion factor.

From the foregoing it will be seen that, to machine a hole 1 in. long through carbon tool steel, a brass electrode 3 in. long will be required and any variations in size at any point along the length of the electrode, any errors of parallelism or bow, or any errors of truth in setting up the electrode will cause inaccuracies in the hole produced. Fig. 2 shows exaggerated examples of these faults and the resultant tapered and oversize holes. From these remarks it will be apparent that the electrode erosion factor will limit the diameter/depth ratio of holes that may be produced to a reasonable degree of accuracy by spark erosion. Theoretically, it should be possible to erode a hole having a minimum diameter of four times the spark gap, in practice about .004 in. dia. using an electrode .002 in. dia. and with care this limit *can* be approached provided that the length of the hole does not exceed

$$\frac{10 \times \text{ELECTRODE DIA.}}{\text{EROSION FACTOR}}$$

This gives a slenderness ratio of about 30 : 1 when using brass electrodes, which appears to be about the practical limit when reasonable accuracy is required.

Greater depths *can* be machined by using other electrode materials with lower erosion factors and further reference will be made to this at a later stage. In addition, the production of small holes is further hampered by the difficulty of providing fluid agitation to remove the eroded particles. Because of the demand for a spark erosion process to produce deep holes, however, considerable investigations into ways of overcoming these problems have been made and a report published recently in the technical press [3] describes the machining of a true hole .035 in. dia. × $4\frac{3}{8}$ in. long through Nimonic 90 by using a specially drawn and straightened hollow brass electrode guided in a bush, pumping dielectric fluid through the electrode at a relatively high pressure, rotating the electrode during cutting and simultaneously vibrating the work table. Other investigations have shown that advantages may be obtained by twisting a wire electrode to impart a slight spiral effect which assists the flow of dielectric fluid, and by slight modifications to the electrical circuits of the machine.

When machining blind, flat-bottomed cavities, it will be necessary to remove the electrode from the machine, re-face the bottom and re-set the electrode a number of times depending on the degree of definition required. Similarly, three-dimensional cavities will require the setting of a number of electrodes to produce the final form, and attention must therefore be given to the means of electrode location so that successive electrodes may be set in true relation to the workpiece, thus avoiding positional and dimensional errors. Fig. 3 shows the stages when machining a cavity. This proceeds roughly in the form of a progression. If the erosion factor is 1, each electrode will remove half the remaining metal and finality will never be reached.

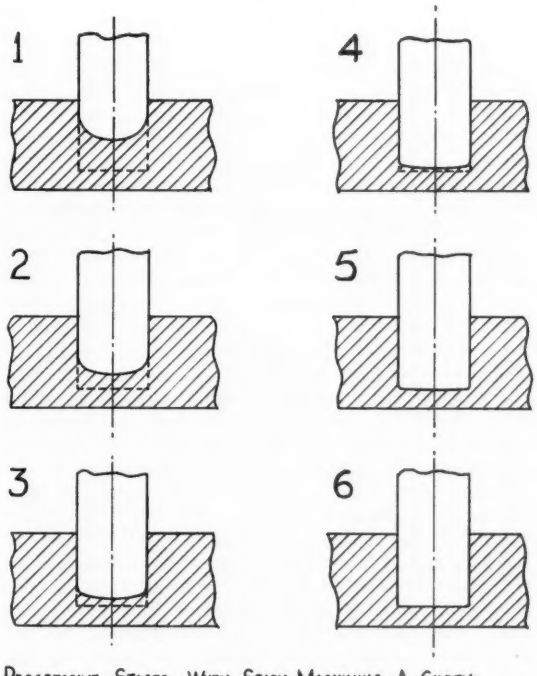
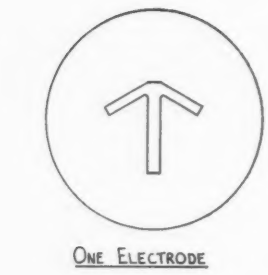
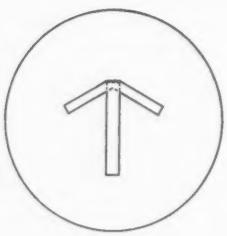



Fig. 3.

PROGRESSIVE STAGES WHEN SPARK MACHINING A CAVITY

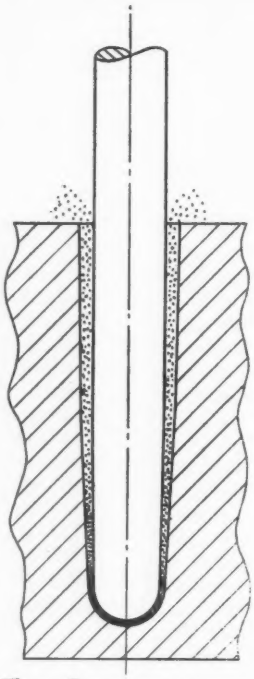


ONE ELECTRODE



TWO ELECTRODES

MACHINING SHARP MALE CORNERS



TAPER PRODUCED IN HOLES

Left: **Fig. 4(a).**

Right: **Fig. 4(b).**

As previously stated, due to the non-uniform field distribution within the electrode, edges and corners erode at a faster rate. Together with the spark gap surrounding the electrode, this limits the degree of corner definition attainable by spark erosion machining. In practice, the minimum radius that can be achieved in a 90° female corner in a horizontal plane is found to be .005 in., while vertical corners may improve to about .003 in. at the top face, tapering to .005 in. at the bottom. Some difficulty has also been experienced when machining sharp male corners due to the tendency of the eroded particles to build up in the sharp female corner of the electrode, thus becoming part of the electrode and eroding the work. It is usually possible to avoid this difficulty by machining the hole or cavity in two parts, as shown by Fig. 4(a). Use of this method also frequently simplifies electrode manufacture.

Apart from errors of parallelism caused by misalignment or weave in the electrode, it is practically impossible to produce an exactly parallel hole by spark erosion. Unfortunately, the spark discharges do not limit themselves to the bottom face of the electrode, but will erode wherever they can break down the dielectric gap. This is assisted by the previously eroded particles which are passing up the gap between electrode and hole and acting as "stepping stones" for a discharge which will readily jump up to three times the critical spark gap value. Thus, when using a parallel electrode, holes of any appreciable depth will always be produced having a taper of about .002 in. per side due to the residual sparking of the walls (Fig. 4(b)). This disadvantage, however, becomes an asset when machining mould cavities which require slight draft angles and also when machining press tool dies where clearance is required for the passage of blanks through the die. In the latter case it is, of course, essential that the die be machined from the back.

One great advantage of the process is the degree of accuracy obtainable when machining small holes and slots. As there is no physical contact between electrode and workpiece, there can be no deflection of the electrode and thus slender electrodes may be used, for example, to correct small errors in hole positions without the usual tendency of a tool to follow the existing hole. Similarly, small holes may be pierced from the back of a die without risk of "run-out" at the top face.

To summarise the accuracy, advantages and limitations of the process, it has been shown that accuracy depends on electrode accuracy, setting accuracy, spark gap setting and design of electrode

and holder. An experienced operator should have no difficulty in producing through holes machined with relatively stiff electrodes to an accuracy of ± .001 in. at the exit face, and even greater accuracy is obtainable by trial and error to determine the ideal electrode sizes and machine settings. Slight tapers will be produced in holes of appreciable length, and an allowance for finishing must be made if a truly parallel hole is required.

Advantages of the process include the machining of difficult materials, the modification and correction of hardened parts, the ability to machine small holes and slots without risk of run-out, cutter breakage or machining errors, the elimination of hand finishing hazards and the close control of die clearances and taper.

Chief limitations are difficulties in manufacture of accurate electrodes, limit in degree of attainable definition, and difficulties experienced when machining small, deep holes.

## finish

The surface produced by spark erosion consists of a large number of tiny saucer-shaped craters, each crater being formed by one spark. It is considered impracticable to apply conventional surface finish measurement techniques to spark machined surfaces, because of the possible formation of undercuts caused by overlapping craters. The surface finish is non-directional and varies with the current density, the workpiece and electrode materials, and with the dielectric fluid used. Generally the harder the material machined, the better the surface finish, and when hard materials such as hardened steel or tungsten carbide are machined using a low current density, the resultant surface has a smooth, matt appearance similar to a fine sand-blasted finish, which is readily lapped to a polished surface by the removal of a few " tenths ". For many purposes, however, subsequent finishing is unnecessary and the spark machined finish may even prove an asset for lubricant retention.

## electrode design

Electrodes are usually made from brass or copper, although a number of other materials such as copper-tungsten, copper-graphite and tungsten-carbide have been used to advantage, having considerably lower erosion factors, but their higher cost and relative unavailability restricts their use to applications where minimum electrode wastage is essential. Tungsten wire may be used to advantage for the piercing of small holes where a high length/diameter ratio is required. Aluminium extrusions have been used for duplicating extrusion dies where cutting rate is of little importance compared with electrode availability. From past experience, brass has been found the most generally suitable material; it has a relatively low erosion rate, is readily available in a wide variety of forms — bar, sheet, strip, tube and various other extruded sections, and is easily machined, formed, or fabricated.

Electrodes may be machined from the solid, cast, stamped, built up by metal spraying or fabricated. For through holes of any appreciable cross-section, electrodes may be made hollow to effect a trepanning operation, the central slug dropping out on completion of the pass. Apart from the saving in machining time due to the erosion of less material, hollow electrodes have the further advantage that dielectric fluid may be pumped through the electrode, facilitating sludge and gas dispersal, resulting in faster, more efficient cutting, less electrode wastage and improved surface finish. Generally, for machining holes more than $\frac{1}{2}$ in. long, trepanning electrodes can

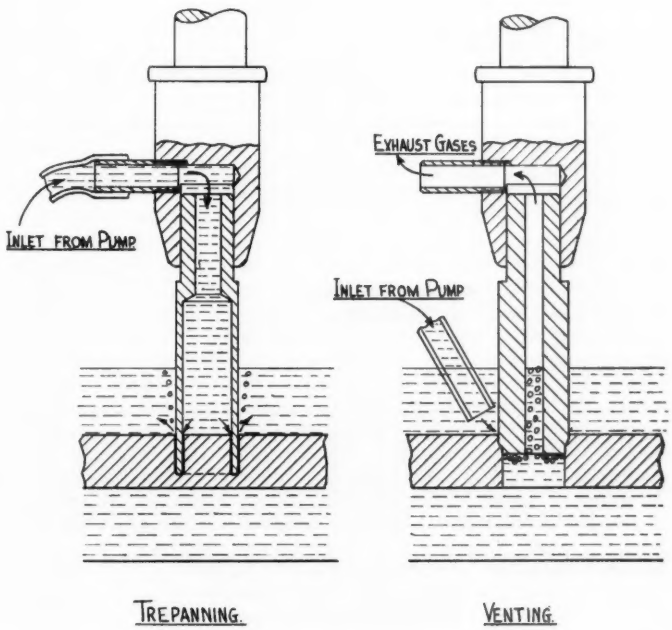



**Fig. 5.**

only be used with relatively high current densities as above this length, if the spark gap is less than about .005 in., difficulty will be experienced in circulating the dielectric fluid between electrode and work with consequent lowering of cutting efficiency. Also, trepanning electrode walls should not be made less than about $\frac{1}{16}$ in. thick as, below this figure, the rate of electrode erosion will rise appreciably. As distinct from trepanning operations, all electrodes will cut more efficiently if they have an axial vent hole and this should be provided whenever possible. It may then be used for dielectric fluid circulation or as a vent only for the discharge of gases as illustrated in Fig. 5.

Electrodes may be mounted singly, or in multiples to cut a number of holes or cavities at one pass. When several through holes of various forms have to be machined in accurate relative positions, the advantage of a multiple electrode will be obvious. Individual electrodes are mounted in their correct relative positions in a holder and the positional accuracy of the eroded holes will then equal that of the multiple electrode, the machining operation being reduced to one simple pass without the need for accurate positional setting. This method complicates the use of individual fluid flow through the electrodes but the "venting" principle may still be used to advantage. A typical example of multiple electrode machining would be a progression press tool die, where the punch plate could be used as electrode holder with electrodes mounted in place of the punches, but with the plate reversed as the die would have to be cut from the back. The same electrodes could subsequently be used to cut the stripper apertures thus ensuring accurate alignment. The cutting of three-dimensional cavities using multiple electrodes is more complicated, because of the need to provide means of locating and changing electrodes while the holder is mounted in the machine. It is, however, quite practical for certain applications, such as the example shown in Fig. 6, for which two electrodes to produce slot cavities in a core bar were mounted in location recesses in a holder, each being secured with two screws.

When considering electrode design for a specific purpose, decisions must first be made on the following points :-

1. whether to produce the form in one cut or rough out first ;
2. what spark gap allowances must be made to produce holes or cavities to the correct size ;
3. how the electrode will be held in the machine ;
4. in the case of cavities as distinct from through holes, how many electrodes will be required for each cavity, and when more than one cavity is to be machined, what total number of electrodes will be required.

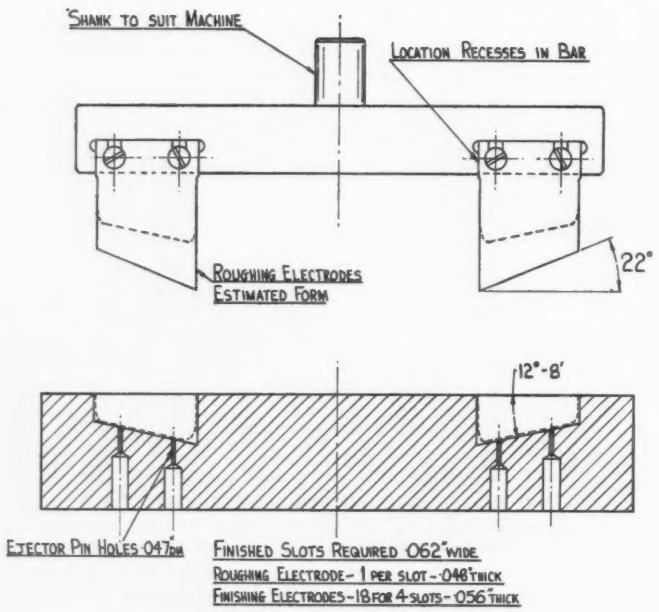
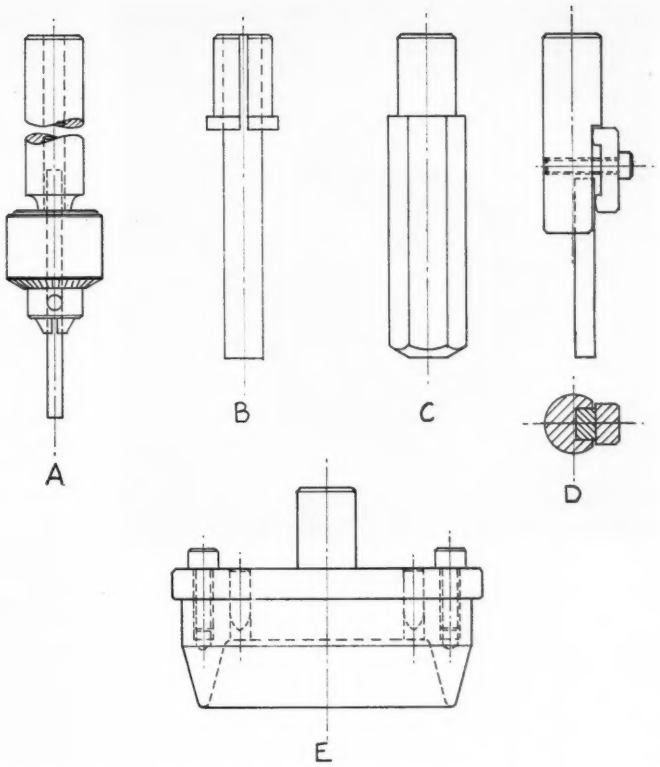

SHANK TO SUIT MACHINE
LOCATION RECESSES IN BAR
ROUGHING ELECTRODES ESTIMATED FORM
22°
12°-8'
EJECTOR PIN HOLES 047"DIA
FINISHED SLOTS REQUIRED 062" WIDE
ROUGHING ELECTRODE - 1 PER SLOT - 048" THICK
FINISHING ELECTRODES - 18 FOR 4 SLOTS - 056" THICK

**Fig. 6.**

Fig. 7.




METHODS OF LOCATING & CLAMPING ELECTRODES.

Taking these points in order, experience shows that when an appreciable amount of metal has to be removed it is always preferable to rough out first. This may be done by normal machining methods prior to heat treatment when producing mould cavities, press tool dies or other parts specifically intended to be finished by spark erosion, by making undersize roughing electrodes for use with high current densities or by making roughing electrodes which are both undersize and of such a form that, after erosion, a cavity will be produced roughly of the form required. An example of this "estimated form" technique is also illustrated by Fig. 6. The form is estimated from previous experience of the expected erosion factor.

Roughing and finishing electrodes may be combined for the machining of relatively short through holes by making stepped electrodes having a front section reduced all round by an even amount, sufficient metal being removed to produce an undersize hole when used at a high current density. After penetration of this section, the current density is reduced and the second section then produces the finished hole. The reduction of the front section may be accomplished either by machining or, more simply, by etching in a suitable acid until the desired reduction is obtained.

Tapered press tool dies can be produced economically using a single electrode, commencing to cut at a high current density and reducing the current density as penetration proceeds, so that on emergence at the die face, a low density is being used for accurate finishing. A tapered aperture will thus be generated having a coarse finish at the back of the die and a fine finish at the die face.

The spark gap allowance must be determined with due regard to the accuracy and surface finish required. This will range from .001 in. at the lowest current densities up to .012 in. to .015 in. at high densities. From experience, to produce accurate holes of fine surface finish, the finishing electrode should be made .002 in. small all round and the corresponding hole can then be machined to a tolerance of $+\ .000$ in. $-\ .002$ in. without difficulty. Roughing electrodes are usually made .015 in. small all round and used at a current density that will produce a hole at least .005 in. small all round for subsequent finishing.

The method of holding the electrode will depend on the shape of the hole or cavity to be cut. Round electrodes may be held in collets or chucks, while electrodes for shaped holes may have round shanks machined on, or attached to, the back face as shown in Fig. 7 at A, B and C. When designing electrodes for multi-dimensional cavities, however, the electrode holder must be so designed to facilitate electrode changing on the machine with positive location for positional accuracy. This may vary between a simple vertical slot and screw clamp (Fig. 7, D), to a holder having pins to locate in accurately positioned datum holes together with appropriate clamping elements, Fig. 7, E.

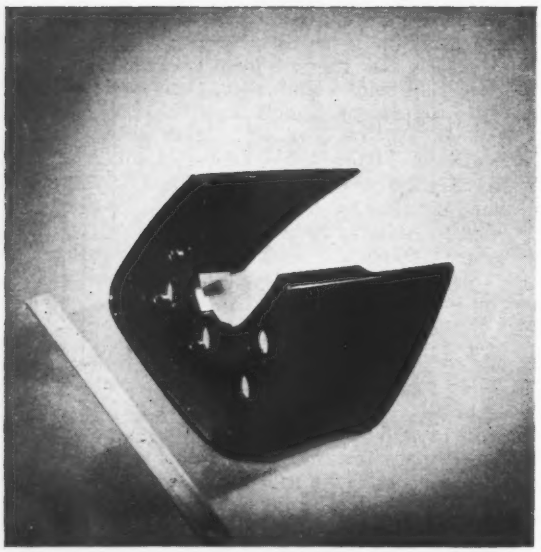


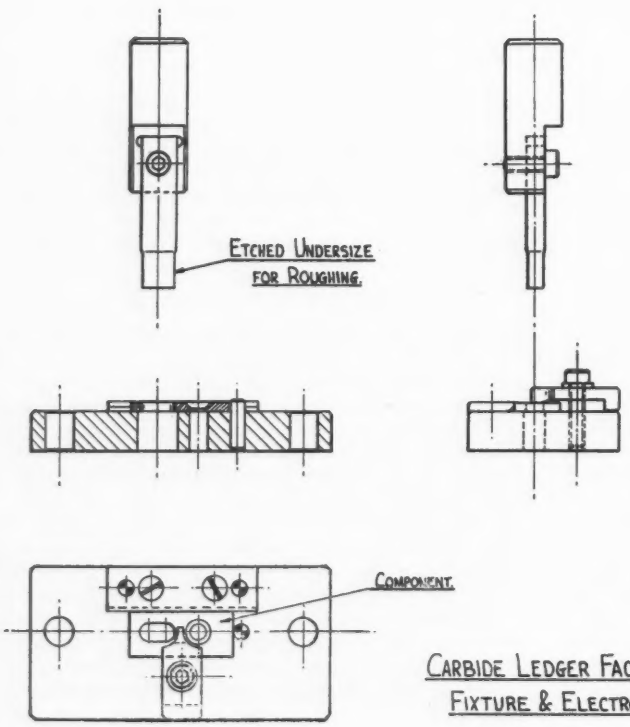
Fig. 8.

It has been shown how the machining of a cavity is progressive and that, theoretically, finality will never be reached. Thus, a form produced from a spark machined cavity will never be as sharp as the electrode used to cut the cavity but for most practical purposes, the use of six finishing electrodes will be found to provide adequate definition and accuracy. This figure can be reduced when a number of identical cavities are to be machined, by providing six electrodes for the first cavity and three for each subsequent cavity. The last three electrodes used for the first cavity are then re-used as the first three electrodes for the next, and so on. No roughing electrodes will normally be required for cavities having sloping sides as the first electrode can be used at high current densities, setting the depth shallow to avoid producing oversize cavities, and subsequent electrodes at lower current densities will clean out all the coarse surface finish left by the roughing pass. Cavities having vertical or near vertical side walls, however, will require the provision of special roughing electrodes, but the number required can usually be limited to one by using the "estimated form" technique previously described.

**specific examples**

Having now assessed the field of application, the accuracy, advantages and limitations of the process, and outlined the general operating procedure, the following examples of work produced have been selected to illustrate the technique of electrode and work fixture design, give some indication of the economics of the process and perhaps provide a guide to others faced with similar machining problems. All the work illustrated was produced on a Sparcatron Mk. I machine, and the time quoted should be viewed in the light of the considerable economies possible by the use of the more powerful machines now available.

The first example (Fig. 8) shows a plastic moulding used in a range of well-known modern cars. Conventional machining of the mould cavity to produce the front peak was considered to be practically impossible, being a non-geometric blend of angles and curves of roughly triangular cross-section having a maximum depth of $\frac{3}{4}$ in., an included angle of 30° and a $\frac{1}{16}$ in. root radius. This form had to be machined into the corner of a cavity already 4 in. deep. Brass electrodes were produced by copy milling.




CARBIDE LEDGER FACING-FIXTURE & ELECTRODE

Fig. 9.

from a master model. Eight cavities were cut and six electrodes used for each cavity, but the second and subsequent cavities were roughed out, using the last three electrodes used for the previous cavity so that only three new electrodes were required. Thus a total of 27 electrodes was needed for the eight cavities, but further economy was effected by making only nine electrodes which were re-cut after use so that each was cut and used three times. Electrodes were provided with location holes which fitted on pins provided on the electrode holder and also on the fixture used for milling the electrode forms, so that accurate positional duplication was ensured. Each cavity took 36 spark machine hours to cut, but it must be remembered that the machine only requires the services of an operator to set up and to change the electrodes as each is expended, and he is thus left free during machine running time for other work such as electrode preparation. Very little finishing of the cavities was required, which was just as well in view of their inaccessible position.

The next example (Fig. 9) shows the method of machining a rectangular tungsten carbide facing, used in the manufacture of cigarettes, which requires the accurate machining of a slot and the provision of a fixing screw hole in the correct relative position. Prior to sintering, the slot and hole are roughed out and after sintering the blank is ground to thickness, width and length. The facing is located on a simple plate fixture after the electrode has been set in correct relation to the fixture locations. The electrode for the slot is made by hot pressing a piece of round brass rod to approximate shape and then form grinding. The front $\frac{5}{8}$ in. is acid etched to provide a roughing section, and the slot is then machined in a single pass, holding both size and position to a limit of $\pm$ .0012 in., including taper. The countersink is next machined using four conical electrodes turned from brass rod and the screw hole finally finished by passing through an appropriate size of brass rod. Total spark machining time for each facing is two hours, including setting time.

Two small press tool dies are shown in Fig. 10. Each die took about 12 hours machine time to erode from solid and was used without any subsequent finishing. The die shown on the left could probably have been produced by conventional methods at about the same cost, but that shown on the right would normally have been made as a split die to facilitate machining or as a two-stage notch and blank die. Spark machining thus effected a considerable economy which was particularly beneficial as only 2,000 parts were required.

The solution to a common die-making problem is shown by Fig. 11, namely, the machining of a die cavity to produce a stamped nut having a conventionally chamfered hexagon — easy to produce by turning on a hexagonal bar but extremely difficult to die-sink. This cavity was cut from a round cavity in $5\frac{1}{2}$ hours machine time.

Dies already hardened and requiring modification or repair form a high percentage of work undertaken.

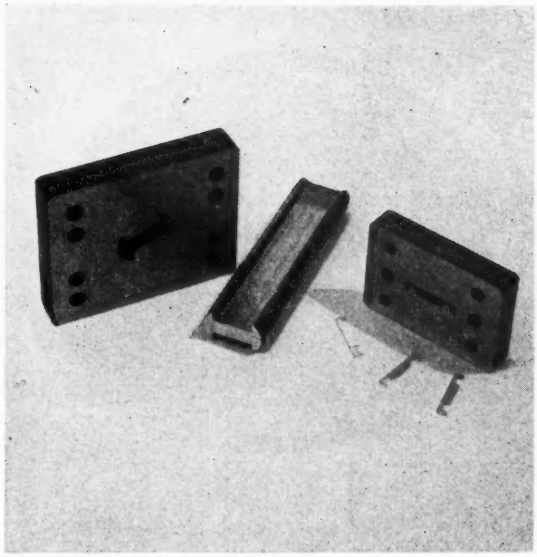
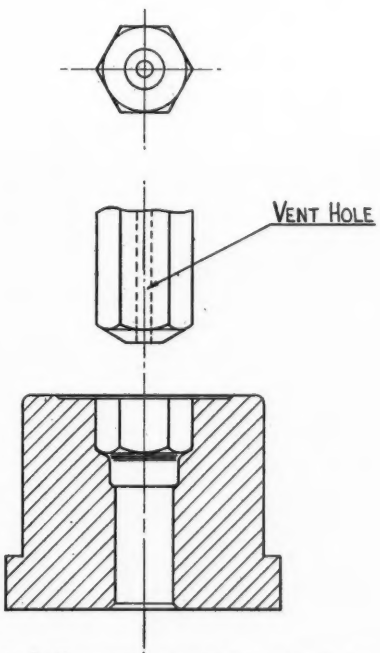


Fig. 10 (above).

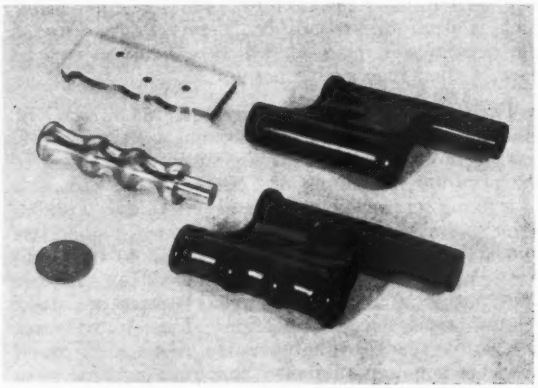
Fig. 11 (below).




ELECTRODE & DIE FOR CHAMFERED HEXAGON NUT

Fig. 12 (left).

Fig. 13 (below).



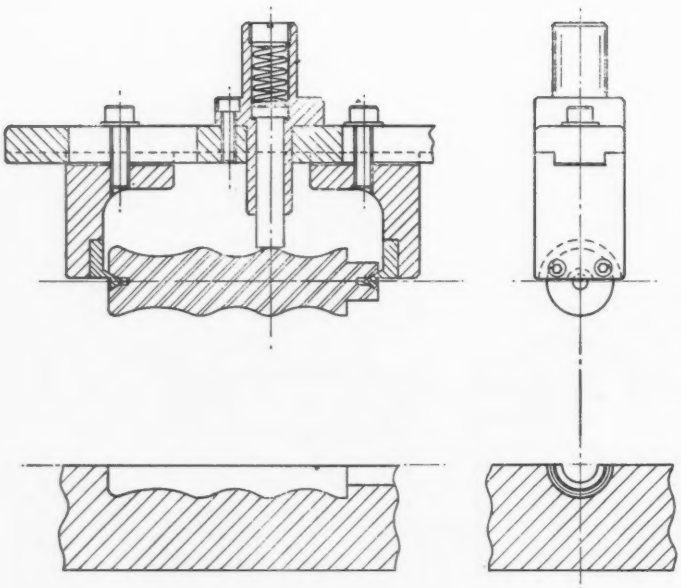


Fig. 14

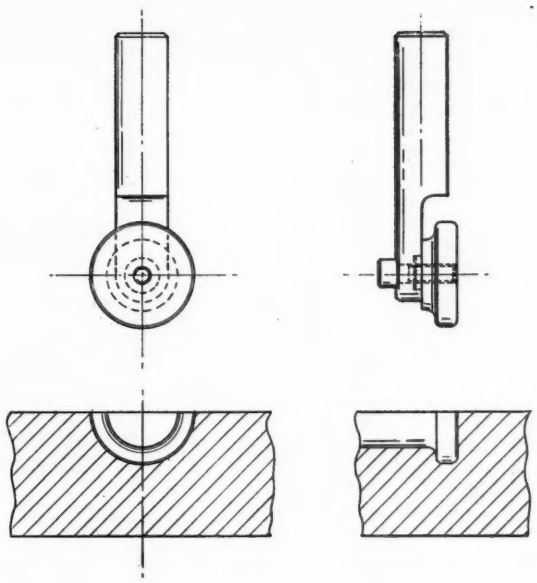
ELECTRODE & HOLDER FOR CAVITIES OF SEMI-CIRCULAR SECTION.

Many only require the addition of extra ejection pin holes, the enlarging of core seatings or the removal of engraved pads. Cutting out damaged sections for inserts can save parts which would otherwise be scrapped and one job in this category, a mould for a radio grill containing some 600 jig bored holes, was received with one corner broken away. A section was machined out, and two screw holes provided for securing an insert, in a total machine time of 12 hours. An insert was fitted and the mould was soon back in production.

Fig. 12 shows an example of a modification carried out to a set of moulds for plastic table ware. The moulded plates were so flat that they were found to stick together by suction when wet. Air slots were required in the base rim of the plates and the first suggestion was to erode six holes in each mould, fit inserts and then machine the inserts to the required shape. On reflection, however, it was decided to lower the base rim .030 in. to leave six bumps standing and this was accomplished using a single electrode, made from brass tube to an estimated form, in 6½ hours per mould. Not only did the estimated form technique reduce the number of electrodes required, but electrode manufacture was simplified, as the six slots were machined straight across the rim, leaving sharp corners and the desired blended effect was produced by electrode erosion.

Fig. 13 shows "before" and "after" photographs of a plastic moulding produced from a die modified by spark erosion, together with one of the electrodes used and the flat form tool used to produce the electrode. Four major modifications were carried out to the expensive die for this part at a total cost of about 10% of the cost of replacement. Two of these modifications, the addition of finger grips along the barrel and the enlarging of the semi-circular rib at one end of the engraved handle, provide interesting illustrations of electrode designs which have proved useful on many occasions. The other two modifications were the thickening of the centre web which was accomplished with a single electrode of estimated form for each cavity, and the repositioning of two side core holes. The addition of finger grips along the barrel was accomplished with the electrode shown in Fig. 13. Electrodes were turned between centres using the flat form tool shown and then mounted in the special holder as shown in Fig. 14. Note should be made of the cut-away centres which enabled the axis of the electrode to be fed down to the die face, and the spring plunger to ensure adequate contact. By rotating the electrode, the whole periphery was used, thus ensuring maximum electrode economy and an accurately generated semi-circular form. A similar principle was used for machining the semi-circular rib cavity at one end of the engraved handle. This was also accomplished using turned electrodes, but in this case the electrodes were fastened to a stem by a screw as shown in Fig. 15.

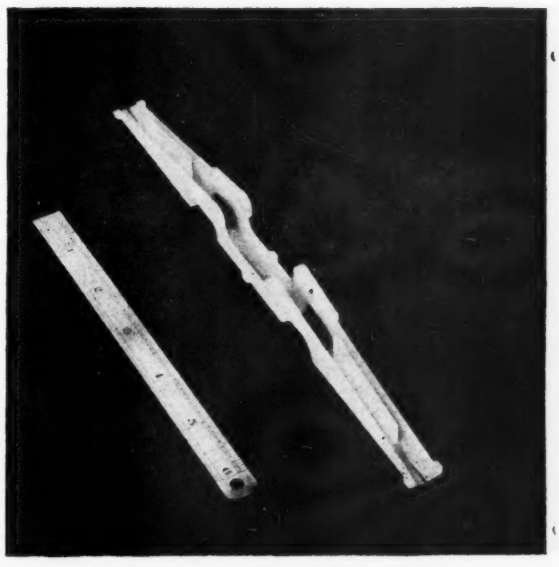
Deep, narrow rib cavities provide a further example of the ideal application of spark machining. The nylon moulding shown in Fig. 16 has two central ribs about 1¾ in. long × $\frac{1}{16}$ in. wide × ¾ in. high at



ELECTRODE & CAVITY FOR CIRCULAR RIB.

**Fig. 15** (above).

**Fig. 16** (below).



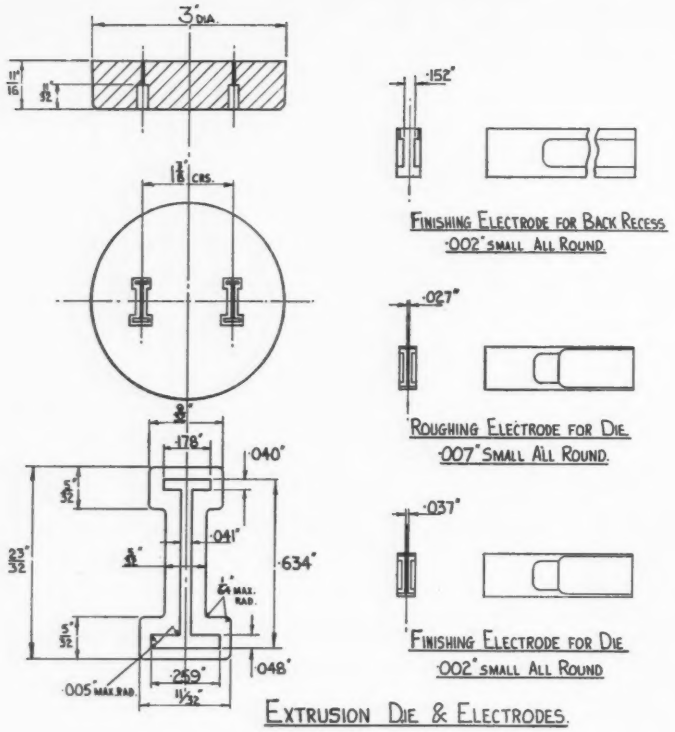



Fig. 17.

the inner end, with sharp vertical corners. Fig. 6, already referred to, shows the electrodes and holder used to machine the cavities for these ribs in the core bar, the two slots being cut simultaneously. Roughing was effected by using a single pair of electrodes of the estimated form shown and six pairs of electrodes were used for finishing. The four $\frac{3}{64}$ in. dia. ejector pin holes were also spark machined after completion of the slot cavities and the total machine time was $23\frac{1}{2}$ hours.

Fig. 17 is a drawing of an extrusion die for curtain rail and the electrodes used to machine it. The extremely narrow slots made electrode manufacture difficult and trouble was experienced during erosion due to build-up in the female corners of the electrodes, which had to be frequently scraped out to ensure that the .005 in. maximum permissible corner radius was not exceeded. Despite this difficulty, the two-impression die was machined, including the back recesses, in 23 hours machine time.

Fig. 18 shows engraving on a curved surface which is readily accomplished by spark erosion. The example shown is a plastic moulding, but the process would be equally applicable to the engraving of tungsten carbide dies for coining operations.

Tungsten carbide pelleting dies provide a further field of application for spark machining, and Fig. 19 shows a typical pelleting die for the production of tool tips, together with the electrodes used to machine it. Spark machining time was 18 hours. Venting is essential for this type of work and roughing was speeded by mounting the die blank, which had been drilled prior to sintering, on a blind ended tube and forcing the dielectric fluid to circulate through the spark gap, thus flushing out the eroded particles Further time was saved by removing the electrode occasionally from the machine and cutting off the eroded front section to assist the dielectric fluid flow.

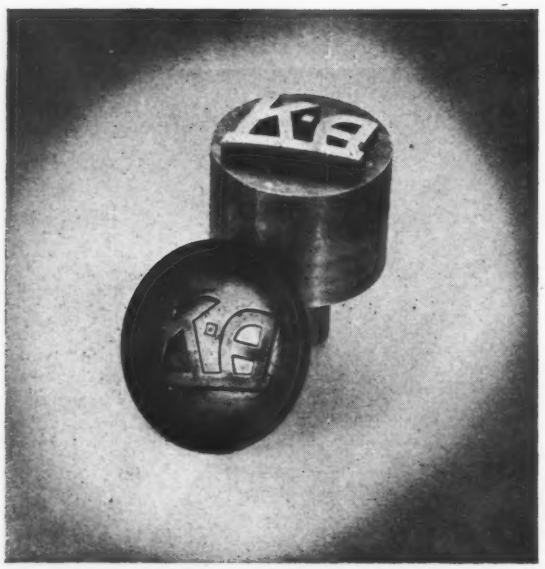
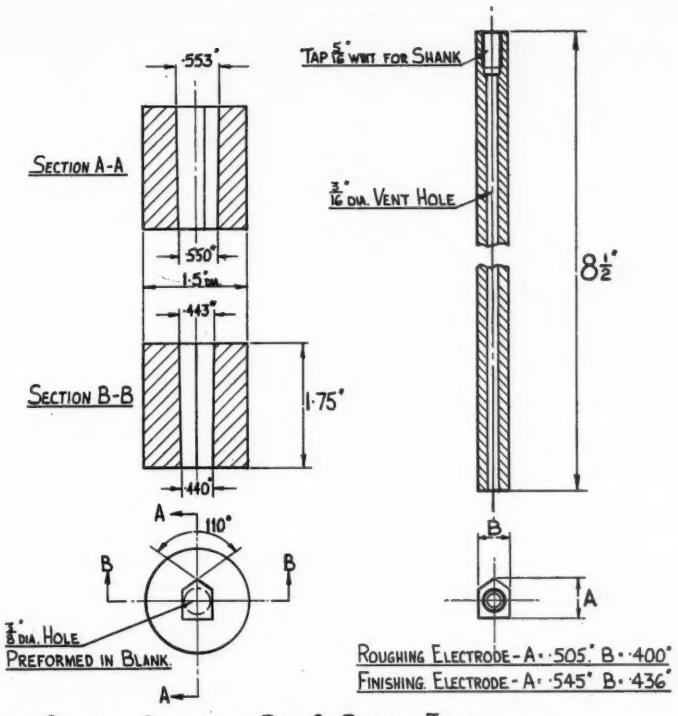


Fig. 18.

Fig. 19.



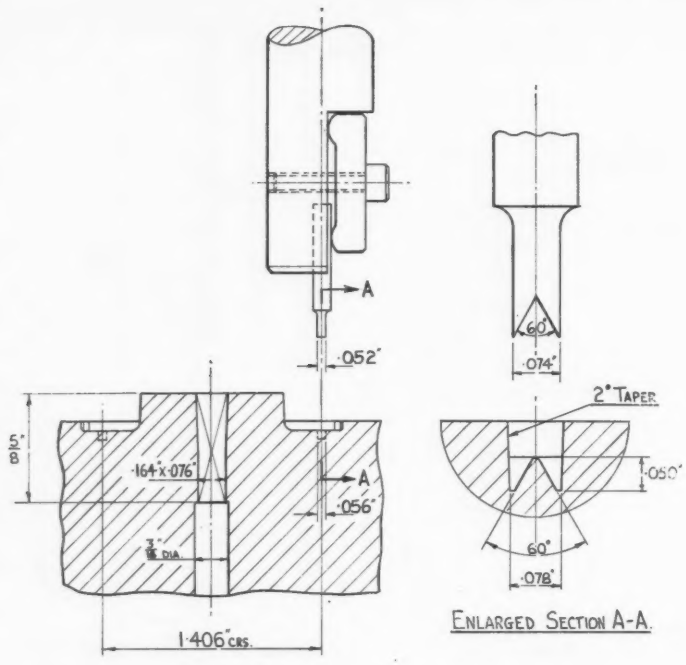

CARBIDE PELLETING DIE & BRASS ELECTRODES.

Another interesting example of spark machining, mainly because of the small size of the cavities, is provided by the stamping die illustrated in Fig. 20. Two cavities, each producing a double fang, are machined into the bottom face of a groove .082 in. wide. The overall dimensions of each double fang cavity are .078 in. × .056 in. In addition, the centre fang hole measuring .163 in. × .076 in. × $\frac{3}{4}$ in. deep is spark machined into a $\frac{3}{16}$ in. dia. hole previously bored from the back of the die. In the first instance, efforts were made to grind the electrodes, but distortion due to heat generation and loss of form due to wheel clogging and breakdown led to the development of a "precision shaping" technique, in which a stationary edge cutting tool was clamped to the spindle housing of a surface grinder and used in place of the grinding wheel. This technique proved so successful that it is now used for finishing all small electrodes, including the forming of radii and other shapes which are first ground into standard toolbits and then precision shaped on to the electrode. Twelve electrodes are provided for the two double fang cavities in each die and the method used is to pass the first electrode to depth in the first position, index to the second position and pass the same electrode to the same depth setting before changing. A new electrode is then mounted and passed to depth in the second position, indexed back to the first position and passed to depth again before changing and so on, thus saving electrodes and setting time. The time to machine both pairs of double fang cavities in one die is $3\frac{1}{2}$ hours but in this instance, due to the frequent settings and electrode changes required, the constant attention of an operator is required.

One of the most interesting applications so far undertaken is the machining of the internal cone and bore of the tungsten carbide nozzle shown in Fig. 21. It is important that the cone and bore, in addition to the close tolerances required, should be truly round and concentric and have identical surface finish and blend conditions to ensure that all nozzles have identical flow characteristics. The nozzles are preformed and sintered with the closest possible dimensional control, and then ground on the external location diameters as truly as possible with the bore. Measurement of the cone position, which controls the bore length, is made by inserting a ball into the cone and measuring the distance to the front face. To allow for possible errors in the sintered blank, it is necessary to leave .020 in. on the ball dimension. After careful checking to ensure that sufficient material has in fact been allowed in the blank, the nozzle is mounted in the fixture shown in position on the machine in Fig. 22.

The fixture consists of a rotatable plate, mounted on ball bearings, having a concentric location recess machined on the axis of rotation to locate the nozzle. Two finger clamps are provided to clamp lightly the nozzle. The periphery of the plate is gear-cut and meshes with a pinion mounted on the spindle of a worm reduction geared motor clamped to the tank. Thus the nozzle is continuously rotated about its own axis while being machined. This has the two-fold advantage of ensuring roundness and concentricity and also spreading erosion evenly over the whole surface of the cone electrode, thus constantly generating a concentric electrode.

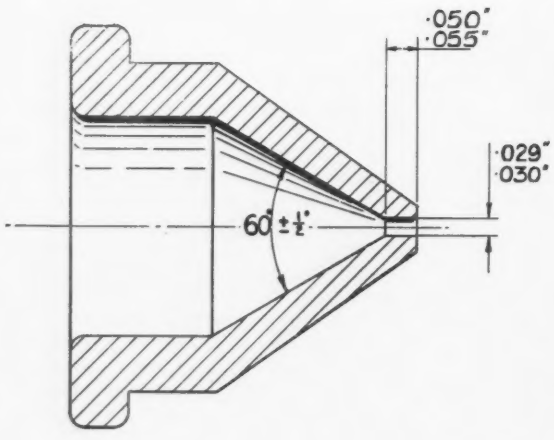
The cone and bore are machined separately. The cone electrodes, which are turned from brass rod, are mounted in the machine chuck and positioned by means of an indicator clamped to the rotating plate being revolved around the electrode. Machining then




ENLARGED SECTION A-A.

ELECTRODE FOR NICHES & STAMPING DIE.

Fig. 20.




CARBIDE NOZZLE.

Fig. 21.

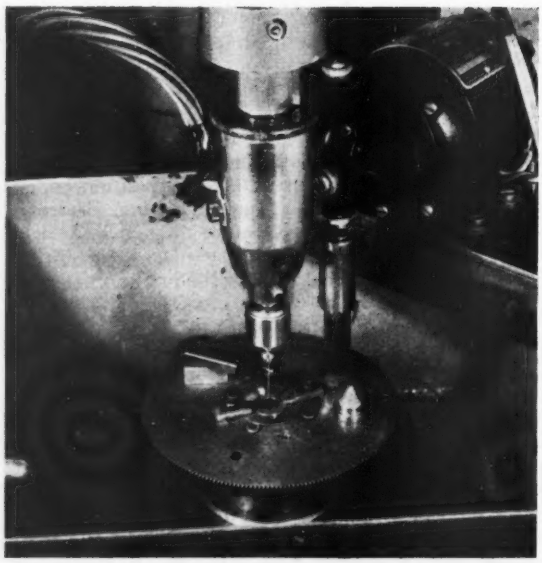


Fig. 22.

commences and continues until the whole surface of the cone has been sparked. The angle of the electrode, which will now be identical to that of the nozzle, is then checked with a maximum and minimum angle gauge. If outside the specified limit, the electrode is changed and the process repeated until the angle is corrected. Machining then proceeds until the correct ball dimension is obtained, an allowance being made for the final bore length, which has a tolerance of .002 in., to be adjusted by grinding from the front face of the nozzle. The nozzle bore is then machined using a wire electrode positioned with an indicator in the same way, the wire being sufficiently small to produce a slightly undersize hole.

The hole is then checked and the wire electrode moved slightly off centre and re-passed through the hole to produce the same effect as internal grinding. This process is repeated until the bore is within the specified limits. The average machining time is $2\frac{1}{4}$ hours each and to date some 150 - 160 nozzles have been completed.

Many other production problems have been solved by spark machining, which has now become part of the regular production procedure. Typical examples are the machining of keyways in cast rotary magnets, throttle orifices in fuel injector sleeves, and slots in waveguide plates, an example of which is shown in Fig. 23. This multiple electrode cuts 80 slots in a brass plate .020 in. thick at one pass in 20 minutes. Slots have a limit of $\pm$ .001 in. on width, length and position. Electrodes are made by "precision shaping".

A further example of a multiple electrode set-up is shown in Fig. 24, but in this case it is used with the multiple work holding fixture shown for the erosion of $\frac{1}{8}$ in. dia. holes in tungsten discs. The fixture holds 25 discs per load, each disc being located in a recess and retained by a leaf spring. The discs are $\frac{1}{16}$ in. thick and machining time is 1 hour per load of 25 discs. Several thousand discs have been pierced by this method.

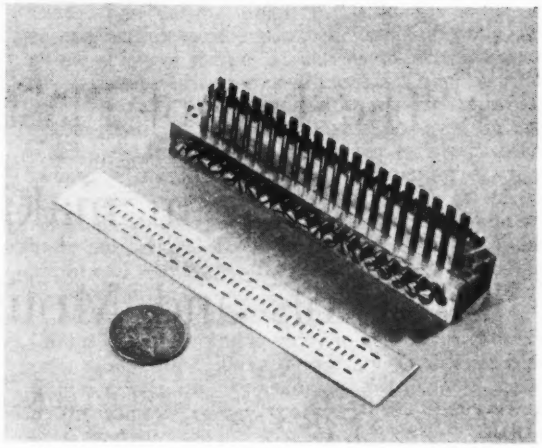


Fig. 23.

## conclusion

The foregoing examples have been selected in an endeavour to show the wide range of application of spark erosion machining already possible but — what of the future ? Machines now available show considerable advance. A Sparcatron Mk. III machine recently installed has shown that many of the times quoted in this Paper could be halved and at the same time electrode wear has been reduced. Additional refinements include fully automatic operation with limit switches which isolate the machine either on completion of the predetermined electrode travel, or in the event of dielectric fluid circulation failure. With these safeguards, coupled with automatic retraction and re-advance of the electrode at preset intervals to facilitate sludge clearance, the machine may safely be left running during the meal breaks or even during the night. Machines are also becoming available with much larger tank capacities able to accept dies weighing several hundredweights, such as those used for drop stamping and forging. Special purpose multi-head machines are being built to overcome specific production problems, thus widening still further the horizon of the production engineer. It is hoped that this Paper has helped to stimulate the interest of production engineers, designers and toolmakers in a process worthy of their attention.

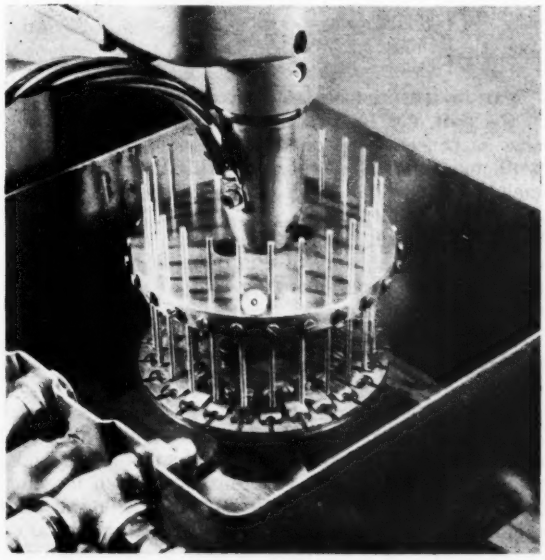


Fig. 24.

## REFERENCES


1. " Principles and Applications of Spark Machining " by D. W. Rudorff. *Institution of Mechanical Engineers. Proc.* 1957. *Volume* 171, No. 14.
2. " Working Metals by Electro-Sparking " by A. V. Nosov and D. V. Bykov. *D.S.I.R. Her Majesty's Stationery Office*, 1956.
3. " Spark Erosion of Deep Holes on a Wickman Erodomatic Machine." *Machinery. Volume* 91, 11*th October*, 1957.

# The Use of Plastics in making Jigs, Tools and Moulds

by W. T. JOHN

*A Paper presented to the South Essex Section of the Institution, 4th December,* 1957

THE aim of this Paper is to describe briefly how plastic tools are made, to illustrate some of the tools of various types that have been made, and to discuss the economics of these tooling processes, their advantages and their present limitations.

## 1. materials

Various plastics have been tried as tooling materials in the past, but for practical purposes attention can now be concentrated on one type only, the class of synthetic resins called epoxides. This Paper will deal exclusively with the use of tooling compositions based on the Epophen epoxide resins made at Southampton by my own firm ; but if there are any lingering doubts about the justice of thus dismissing other types of plastics for general tooling, I shall be delighted to help dispel them.

The Epophen resins used in tooling are syrupy liquids which can be converted into rigid solids by mixing with suitable "curing agents" or hardeners. This change is brought about by a chemical reaction, normally at room temperature, in which nothing is eliminated : there are no by-products formed, no solvents to be removed. It is this fact which largely accounts for the supremacy of epoxide resins in tooling, because it leads to a most important characteristics of these resins, namely, almost complete absence of shrinkage on setting.

In practice other ingredients are added to the resin/hardener mixture to improve the properties of the final composition. Fibrous fillers like glass-fibre, jute or sisal are incorporated to increase tensile strength, rigidity and impact resistance where needed, in addition to powdered fillers of various kinds to impart better wear-resistance; granular materials like silica sand for high compression strength, low thermal expansion and cheapness; metal powders for greater heat conductivity; and liquid modifiers to give flexibility and shock-resistance. From this it will be obvious that we are concerned here not with one resin or plastic but with, literally, innumerable different compositions from which the task is to select those best suited to particular tooling jobs. A few of the more commonly useful Epophen compositions, and their uses are shown in Table 1, while their properties are given in Table 2 (*pages* 712-713).

## 2. methods

All the methods of producing plastic tools have one feature in common : they make use of the *plasticity* that characterises these synthetic resin compositions. Tool shapes are obtained by *moulding*, i.e. by casting, trowelling, laminating or some combination of these, while the composition is still in a liquid or semi-liquid state, and allowing it to harden in contact with the mould or pattern. No machining or hand-working is needed.

Clearly the first requirement is something which will provide the required form. This may be a model or negative pattern (mould) in wood, plastic, wax, clay, metal, plastic or any other conveniently shaped material. It should be as smooth of surface and as accurate in dimensions as the final tool is required to be. It will also need special treatment to seal its surface if it is of plaster, and a thin coating of wax or other "release agent" to prevent the epoxide composition from sticking to it. It should be noted that the pattern is made precisely to the dimensions required in the final tool, since shrinkage of the Epophen tool mix is negligibly small—about 0.001 in. per foot, or 0.025% by volume.

For making new press-tools in Epophen (as distinct from duplicating an existing tool) there are usually two ways of providing the required shape:

(a) by making an accurate model (normally in wood) of the punch; or
(b) by using a pressing or hand-beaten panel.

The punch-model is the more generally applicable method; a pressing may be unsuitable because of spring-back, or of thinning of the metal. When starting with a single model, it is obviously necessary to make provision for the correct clearance between punch and die. This is normally done by applying special sheet wax of the proper thickness to the punch model (or the plastic punch tool itself) and casting the die against the waxed surface. In certain cases, e.g. some drop-hammer tools, the flexibility of the Epophen composition used makes it possible to reduce or even dispense with this clearance. In consequence, a better quality pressing may be obtained.

When the objective is a mould, e.g. for forming other types of plastics by injection-moulding, then it can be reached in one step by simply casting or laminating the Epophen composition against the surface of a model (which may be an existing component). In the same way an Epophen checking-fixture is taken directly from a master, the surface of which it will reproduce precisely.

There is no cheaper way of producing complex forms than casting them, if, as in this case, the casting neither shrinks nor expands significantly, and where the tool design is such as to permit casting this is therefore the preferred method. Other methods, and especially lamination with epoxide resin and fibrous reinforcement, are indicated, however, for tools which need to be light in section but yet mechanically strong. A drill jig or checking-fixture, for example, may need to be only about $\frac{1}{4}$ in. - $\frac{1}{2}$ in. in section thickness. A fibreless casting composition would not have more than 10,000 p.s.i. flexural strength, and might easily be broken if handled roughly. By making it as a laminate with glass-cloth, flexural strength could be raised to 50,000 p.s.i. without difficulty. A similar argument might apply to a foundry core-box, or a mould for making plastic boat-hulls: here the thin section in the Epophen mould is dictated mainly by the economy of tooling material resulting from the deep shape.

It will be evident that these two methods — the casting method and the laminating method — can sometimes be *combined* with advantage. It is indeed in the choice of the most fitting method and in the design of the tool itself that experience in plastic tooling counts most. The details of the actual casting or laminating operations, though equally important, can be learned quite easily and quickly.

When epoxide castings more than 1 in. or 2 in. in thickness are called for, it is often advantageous (and sometimes imperative) to use a cheap (because highly-filled) composition for the bulk of the tool, and a facing only about $\frac{1}{2}$ in. thick of the mix which gives the required surface characteristics. For press-tools, as an example, Epophen mix 8 is used to give a resin-bonded sand core, costing (for materials) less than £10 per cubic foot. This may be faced with mix 3 costing about £25 per cubic foot, and the weight of facing mix may be only 10% of the total for a tool weighing about 3 cwt. This would bring the total material cost down to about £11 per cubic foot.

Some large tools, like foundry patterns, models, or even certain stretch-formers as used in the aircraft

★ ★

*Mr. John is Development Engineer of Leicester, Lovell & Co. Ltd. He was born in Swansea, and after War-time Army service, studied engineering and foundry technology at Loughborough College.*

*After spending several years in the foundry industry, he joined his present firm, where he has specialised in engineering applications of modern synthetic resins as applied to the engineering, aircraft and automobile industries.*

## DATA SHEET FOR TECHNICAL SERVICE BULLETIN 310c

The following EPOPHEN compositions are commonly used for tooling (all proportions in parts *by weight*):—

**TABLE I**

| Mix | Resin | | Hardeners | | | | | | | | Modifier | Fillers | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref. | 841 | M-1075 | 702 | 715 | 219-88 | M-1123 | M-1122 | M-1109 | M-1015 | M-5013 | M-5011 | 718 | Sand | Talc. | Iron Pdr. | Remarks |
| 1 | 100 | — | 6 | — | — | — | — | — | — | — | — | 100 | — | — | — | Differ in working life of liquid-cured products all hardwearing. |
| 2 | 100 | — | — | 12 | — | — | — | — | — | — | — | 100 | — | — | — | |
| 3 | 100 | — | — | — | 15 | — | — | — | — | — | — | 100 | — | — | — | |
| 4 | — | 100 | — | — | — | 75 | — | — | — | — | — | 100 | — | — | — | Slightly tougher than mixes 1, 2 or 3 |
| 5 | — | 100 | — | — | — | — | 66 | — | — | — | — | 100 | — | — | — | |
| 6 | — | 100 | — | — | — | — | — | 112 | — | — | — | 100 | — | — | — | Tougher, more flex. than 4 or 5 |
| 7 | 100 | — | — | — | 15 | — | — | — | — | — | — | — | 500 | — | — | Original sand core mix |
| 8 | — | 100 | — | — | — | — | 66 | — | — | — | — | — | 500 | — | — | Improved ditto |
| 9 | — | 100 | — | — | — | 75 | — | — | — | — | — | — | — | 130 | — | Thixotropic model mix |
| 10 | — | 100 | — | — | — | 75 | — | — | — | — | — | — | — | — | 300 | Moulds for Metallizing |
| 11 | — | 100 | — | — | — | — | — | — | 40 | — | — | — | — | — | 800 | Heat-conductive moulds poured at 120°C. used to 160°C. |
| 12 | — | 100 | — | — | — | — | 66 | — | — | — | 60 | 100 | — | — | — | Tough, for drop hammer dies |
| 13 | — | 100 | — | — | — | — | 66 | — | — | — | 80 | 100 | — | — | — | More flex. for drop hammer punches |
| 14 | — | 100 | — | — | — | — | — | — | 40 | — | — | — | — | — | — | For high temp. laminates |
| 15 | — | 100 | — | — | — | — | — | — | — | 35 | — | to 20 | — | — | — | Bonding mix |

### NOTES

1. **Resin** M-1075 gives better resistance to heat and is less irritant than Resin 841, but is slightly more expensive.
2. **Hardeners** 702, 715 and 219/88 are liquid and slightly volatile polyamines, which are highly reactive and therefore capable of causing skin irritation.
3. **Hardeners** M.1015, 1109, 1122, 1123 and 5013 do not contain volatile or liquid amines, and appear to be non-irritant. Their use in conjunction with Epophen Resin **M-1075** is therefore recommended where minimum risk of skin reaction is important.
4. **Modifier** M.5011 is a polysulphide rubber which reacts with the Epophen resin/Hardener system, increasing flexibility and shock-resistance at the expense of hardness and heat-resistance.
5. **Filler** 718 is a specially selected grade of slate flour which gives excellent wear-resistance and other desirable properties.
6. **Sand** used as a filler in mixes 7 and 8 is dry, clay-free silica sand of moderate coarseness. Suitable grades can be supplied.
7. **Talc.** The particular grade recommended is F.M.20 ex Binney, Smith & Ashby Ltd., London.
8. **Iron Powder.** When a fine smooth surface is to be made, Swedish Sponge Iron Powder (ex Powder Metallurgy Ltd., London) is suitable. For general work a cheap but suitable grade is spent shot-blast grit, readily obtainable as foundry waste.

## DATA SHEET FOR TECHNICAL SERVICE BULLETIN 310c

Properties of the more important Epophen tooling compositions (see Table I) are as follows:—

**TABLE 2**

| Mix | Before Cure | | | | | | After Full Cure (Hardening) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref. | Viscosity (poises) | Usable Life Hours | Cure Period (R.T.) | Density 21°C. | Expansion | Heat Limit °C. | Hardness Brinell | Impact ft. lb. | Modulus EX10° | Tensile p.s.i. | Flexural p.s.i. | Compressive p.s.i. |
| 1 | 200 | ½ | 1 day | 1.7 | 50 | 85 | 30 | 0.0350 | 1.6 | 4,500 | 11,000 | 25,000 |
| 2 | 170 | 5 | 2 days | 1.7 | 50 | 85 | 30 | 0.0350 | 1.6 | 4,500 | 11,000 | 25,000 |
| 3 | 160 | 10 | 3 days | 1.7 | 50 | 85 | 30 | 0.0350 | 1.6 | 4,500 | 11,000 | 25,000 |
| 4 | 250 | ¾ | 1 day | 1.7 | — | 120 | 28 | 0.04 | Less than 1.5 | 5,300 | 9,000 | 18,000 |
| 5 | 275 | 4 | 2 days | 1.7 | — | 120 | 28 | 0.04 | Less than 1.5 | 5,300 | 9,000 | 18,000 |
| 6 | More than 500 | ¾ | 1 day | 1.7 | — | 45 | — | 0.08 | Less than 1 | 2,200 | — | 12,000 |
| 7 | Just pourable | 10 | 3 days | 1.8 | 23 | 165 | — | — | 2.5 | 1,750 | 3,000 | 108,000 |
| 8 | Just pourable | 4 | 2 days | 1.8 | More than 30 | More than 165 | — | — | Less than 2.5 | (2,000) | (2,500) | (90,000) |
| 9 | — | ¾ | 1 day | 1.6 | — | (130) | (18) | — | Less than 2 | (4,000) | (8,000) | (16,000) |
| 10 | pourable | 1 | 1 day | (3.0) | (45) | (160) | (32) | — | (2.2) | (5,300) | (9,000) | (18,000) |
| 11 | pourable | ¼ | (120°C.) 1 hour | (3.8) | (20) | (170) | 38 | — | More than 2.5 | — | — | — |
| 12 | 150 | 6 | 2 days | (1.65) | More than 50 | — | — | 0.26 | 0.09 | (2,000) | — | (10,000) |
| 13 | 125 | 7 | 2 days | (1.65) | More than 60 | — | — | More than 0.35 | Less than 0.09 | 1,600 | — | (8,000) |
| 14 | (45°C.) 30 | 2 | (120°C.) 1 hour | (1.2) | — | 150 | — | — | — | — | — | — |
| 15 | More Than 500 | 2 | 1 day | (1.2) | — | (40) | — | — | — | (3,000) | — | — |

### NOTES

1. **Viscosity** in poises at room temperature unless otherwise stated.
2. **Cure Period** here means approx. 90 per cent. of complete cure. Much shorter periods may be adequate for certain uses. Subsequent oven-curing (12 hours at 60°C. unless otherwise indicated) is required to give strength and other properties tabulated.
3. **Density** in gms./cc.
4. **Expansion** coefficient (linear) per °C. by $10^{-6}$.
5. **Heat Limit** is Distortion Point in °C. (A.S.T.M. method, D648-45T, 66 p.s.i. fibre stress).
6. **Hardness** determined in Barcol units and converted to Brinell figures shown.
7. **Impact** strength in foot-lb., notched specimen, Hounsfield Impact Tester.
8. **Modulus** of Elasticity in Tension, p.s.i. by $10^{6}$.
9. Figures in brackets are approximate or preliminary data subject to confirmation.

industry, are not subjected to heavy loading in use. In these, further economies can be made by using cheap low-density core materials such as foamed phenolic resins, polystyrene plastic beads, vermiculite, solid timber or even an empty box structure. Clearly, there are many ways in which a little ingenuity can cut material costs in tooling with epoxide plastics.

It is convenient at this point to consider two ways in which metals and plastics can be combined with advantage to give composite tools of superior performance.

In the first place, it is necessary to recognise that in strength, hardness or wear-resistance, cast epoxide resins cannot compete with tool steel. Press tools capable of producing 100,000 pressings when made in steel (and suitably lubricated) cannot be expected to give more than perhaps 20,000 pressings from 20 s.w.g. (0.038 in.) mild steel sheet, if the working surface is entirely in epoxide plastics; and if radii less than about $\frac{3}{16}$ in. are involved, the output from the plastic tool may well drop to 5,000 or less, depending on the severity of the draw. It is, of course, especially in short-run tooling that the speed and economy of tooling in plastics is most attractive; but it is clearly desirable to extend the scope of the plastic tooling if it can be done.

One way of achieving this, which is quite widely practised in the U.S.A. but as yet very little in Britain, is to use machined steel inserts at points of heavy wear, such as the edge of the die cavity. An extension of this principle is to use such steel inserts for trimming and piercing operations which the plastic itself could not perform at all. Use of such a trim-die in epoxide resin plus steel cutting edge for the roof panel of an American car body was described recently.

A second way of combining steel with plastics in order to get the best out of both is to provide an Epophen plastic tool with a steel skin. We have developed a process for doing this by spraying suitable steel alloys on to the prepared surface of a mould and, when a sufficient thickness of metal has been built up, backing it with the appropriate Epophen composition. This is allowed to harden in the usual way, and on removal from the mould brings the steel skin away with it. Results have shown that the press tools made in this way have very much improved wear-resistance and may approach or even surpass solid carbon-steel tools in suitable work. The process of making metallised plastic tools in this way (which is covered by a patent application) is not as simple in practice as it sounds, but the details can be learned and operators trained in our Southampton works.

### 3. economics

Experience in making some hundreds of tools with Epophen over the last three years, either in our own Plastic Tooling Department at Southampton or on customers' premises, has shown that the cost of a completed Epophen tool is usually about 30% of the cost of a conventional solid metal tool. Some of the plastic tools made have shown as much as 90% saving in cost, but this is usually possible only when replication is involved: if, for instance, a couple of dozen patterns or core-boxes are wanted for repetition work in a mechanised foundry, they can all be made in Epophen from a single master pattern at very low labour cost; the alternative would be to machine and hand-dress each tool separately in metal — an expensive process if complex shapes are involved and close tolerances must be held.

On the other hand, there are many tools which would cost more to make in plastics than in steel. The deciding factor here is the complexity of form: simple rectangular or cylindrical tools, for example, can usually be machined more cheaply in steel than cast or laminated in plastics.

In comparing costs in this way, it may be necessary to take into account the useful life of the tool. It should not, however, be supposed that if 50,000 pressings are required over a year from a plastic tool that will only produce 10,000, the tooling cost for the whole job will amount to five times the cost of the first tool. It will be very much less, for these reasons:-

(a) the limit of output will usually be set by wear occurring on either punch or die, but not on both simultaneously;,

(b) on tools of substantial size it pays to renovate, when wear becomes excessive, by chipping away the original facing and applying new facing to the old core;

(c) by retaining a permanent model or mould in plastic when the tool is first made, the cost of producing subsequent replicas is reduced to a minimum.

To give a specific example, the cost of making a fairly large punch and die, including the original wooden model of the punch, amounted to about £200. After an initial run it was realised that requirements were likely to range between 20,000 and 50,000 panels, whereas the un-metallised plastic tool was expected to make 5,000 - 10,000 pressings before showing excessive wear at about the same rate in punch and die. Before wear could begin, impressions were taken in quick-setting plastic from both parts, at a cost of some £20. These served as permanent moulds for re-surfacing of the tools whenever required. After 7,000 pressings, the tools were re-surfaced by chipping back and casting a new facing on the old cores. Cost of renovation amounted only to some £80 — less than half the cost of the first tool, which in turn was reckoned to be one-third the cost of making the same tool in steel. In fact five or six plastic tools could be made, if and when required, for the cost of one steel tool.

Since time means money, it often pays to make tools in plastic first, in order to get production started with a minimum of delay, while conventional steel tools are being made. This procedure may have the further advantage of disclosing the need for tool modifications before the expensive metal tooling has proceeded too far to be altered.

## 4. advantages

The most important, but also the most obvious, advantages of epoxide resin tooling are low cost and speed of production. Of these, the cost saving has already been discussed. Speed in completion of plastic tooling is most evident when complex matching tools are involved : it is the ability to cast a die to a punch so that they mate exactly, without any hand-work, or to produce an injection-mould as a direct impression from an existing component, which can lead to so large a saving in tool preparation time. It is, in fine, the absence of shrinkage on these Epophen compositions which is the basis of their usefulness.

Some other advantages of epoxide plastic tooling might escape notice and are, therefore, worth mentioning here : low density (ease of handling) ; corrosion-resistance (can be stored out-of-doors) ; self-lubrication (especially valuable in tools, e.g. for paper-forming, that must be run *dry*) ; easy modification (extra material can be built on to an Epophen tool by simple casting or laminating steps) ; improved release-properties (important in foundry patterns and core boxes) ; and electrical insulation (of special value in high frequency jig work).

## 5. limitations

In view of the striking advantages claimed for epoxide plastics, why are they not more widely used? A frank answer to this question would be partly because of the natural limitations of epoxide resins, and partly because of the (less natural?) limitations of those who could use them.

The main weaknesses of epoxide compositions as materials for tooling are, in comparison with tool steel, inferior tensile shear and impact strength, lower hardness and poor thermal conductivity. By suitable choice of resin, hardener and filler, it is possible to minimise the effect of these materials limits — but the minimum remains. (Were it not so, there would be few uses left for steel!) Suitable tool design can often compensate for the relatively low tensile value of the plastic by providing reinforcement, either with glass or similar fibre, or with metal framework. Alternatively, it may be possible to provide adequate strength by increasing section thickness. In some forming-tools, however, these remedies will not serve. Figs. 1 - 5 may illustrate these points.

Impact strength can easily be provided by use of modifiers which make the resin flexible and resilient, or by adding enough fibre; but the former reduces hardness and the latter reduces wear-resistance. Since drop hammer tooling is used for short-run work only, a satisfactory hardness/toughness balance is readily obtained for this type of tool. The real problem arises with tools of most other types in which maximum hardness and rigidity are required, which are not subjected to heavy shock loading during normal service, but which are in fact liable to severe damage as a result of accidental mishandling. The reinforcing methods indicated in Figs. 2, 3 and 4 may limit the effect of accidental dropping to a chipping of the

(*continued overleaf*)

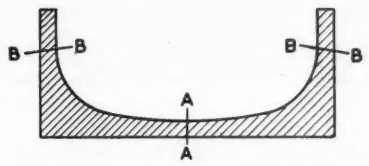



**Fig. 1. Cast plastic drop hammer die easily broken at A/A and B/B.**

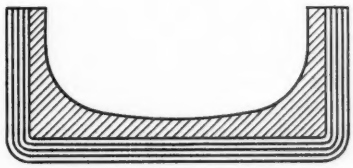


**Fig. 2. Laminated backing, cast face, does not break.**

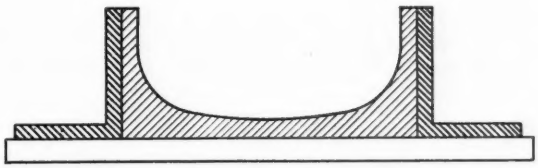


**Fig. 3. Steel base plate L-iron bolster.**

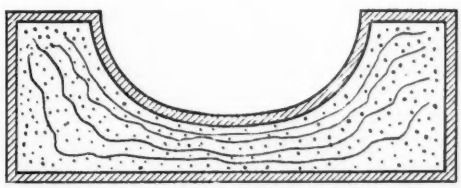


**Fig. 4. Increased section provides strength needed.**

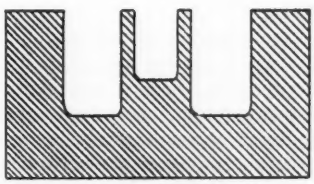


**Fig. 5. Impossible in plastic tooling.**

# INTERNATIONAL CONGRESS for PRODUCTION ENGINEERING RESEARCH

THE International Congress for Production Engineering Research, which has recently held its eighth annual assembly, draws its membership from 12 different countries. Each country is restricted to about four members, who must be responsible in some way for the direction of research into production engineering. The annual gathering, when Papers are presented and discussed, meets in a different country each year, and this year has been held for the first time in England.

The Production Engineering Research Association of Great Britain was the host body for the Congress, being responsible for all the arrangements for the meeting, which was attended by representatives from Australia, Belgium, Great Britain, Czechoslovakia, Finland, France, Germany, Holland, Italy, Sweden and Switzerland.

As a contribution to the procedings, The Institution of Production Engineers gave a dinner at Leamington Spa, in honour of the delegates. The arrangements for this function were made by the Institution's Midlands Region Committee, and Mr. H. Tomlinson (Chairman of the Region) was in the Chair for the evening, supported by a number of senior members from the Region, who assisted him in his duties as host.

During the course of the Dinner, Mr. E. W. Hancock, O.B.E., Past President of the Institution, and member of PERA Council, proposed a toast to the success of the Congress. Mr. Hancock said:

I COUNT it a privilege to be asked to propose the toast to the members of the International Congress for Production Engineering Research and to couple this toast with the name of your President, Professor E. Bickel. Also, I have been asked to include in this toast a brief history of the formation of the first Production Engineering Research Centre in this country, and I propose therefore to deal with this first.

---

## "THE USE OF PLASTICS IN MAKING JIGS, TOOLS AND MOULDS"

— concluded from page 715

surface, which if small enough can be repaired easily and quickly by applying more of the original facing-mix, finally dressing to shape. The fact remains that such hard plastic surfaces are more readily damaged than steel, and production is held up for repairs however quickly these are done. A glass-laminate surface on the tool will be much less liable to such damage; but the wear-resistance of the fibrous surface is vastly inferior to that of the more brittle cast Epophen mix. If this problem becomes acute in practice (because proper care in handling tools can not be guaranteed), a solution is now available: the tools can be metallised, with a laminated backing to the metal skin.

Low heat-conductivity is not a significant limitation on epoxide plastic tooling except in the special field of heatable moulds, such as matched dies for reinforced plastic moulding, where heat has to be supplied to the moulding through the tool, or in injection-moulding of thermoplastics where heat-removal is required. Metal powder fillers improve conductivity, but not enough. The best way round this difficulty seems once more to involve the use of a sprayed metal skin.

It will be seen that even when these inherent limitations of tooling plastics are accepted, there remains a vast area of useful application for plastic tools. At a rough estimate, present usage of epoxide resins for tooling in Britain is less than one-tenth of 1% of what it could usefully be, for two main reasons: the reluctance to experiment which still afflicts British industry to a limited degree; and, more important, the shortage of engineers with a working knowledge of these new plastics. Without such knowledge, supplemented where possible from the specialised background of the resin maker, the tool designer either remains ignorant of the potentialities of plastic tooling, or experiments with the wrong composition, under the wrong conditions, to make the wrong type of tool — with the inevitable and predictable results.

*This* problem — the problem of communication — is surely one to which organisations like The Institution of Production Engineers can provide a ready solution.

One has to be very careful, in giving an historical review, to be sure that one's imagination does not gain precedence over one's memory, or indeed over the facts. I, of course, well remember the very first discussions at Council Meetings and Committee Meetings of The Institution of Production Engineers relative to the formation of a research centre. This was on 20th June, 1936, when The Rt. Hon. The Lord Sempill was President. I had, at that time, just relinquished office as Chairman of Council, and continued as a Member of the Council during the period in question, when an exploratory committee was set up in June, 1936.

The first public reference to the formation of a Research Centre by our Institution was given over 20 years ago, at the 14th Annual Dinner held in London on 29th October, 1937. The President at that time was Lord Nuffield. Lord Austin (who was a Past President) proposed the Toast to the Visitors, coupled with the name of Dr. H. Schofield, the Principal of Loughborough College, Leicestershire, at that time.

Lord Austin said that he hoped Dr. Schofield would make some reference to the importance of production engineering research. Dr. Schofield, in his reply, said that he was interested in the pioneering steps which the I.Prod.E. had taken. Dr. Schofield called our attention, at that time, to an international authority — Dr. Georg Schlesinger — indicating that such a man would be most valuable in charge of a laboratory for production engineering research.

**realisation of the need**

There was considerable enthusiasm during the years 1937 and 1938 by members of our Council and other Committees. We were all fully convinced of the need for a research centre in production engineering. Whilst the men in the Institution at that time had a great deal of experience and "know-how", there was a lack of basic knowledge in the more scientific aspects of production engineering. Our eyes were further opened by the Paper Dr. Georg Schlesinger presented in 1937, entitled "Practical Research in Production Engineering". This Paper was presented in London, Manchester and Birmingham, and brought home to us the need for a more basic approach to our day-by-day problems of production.

It was at the 15th Annual Dinner of the Institution, held in London on Friday, 21st October, 1938, that the President — Lord Nuffield — in his after-dinner speech made the following statement:-

> "Anyway, I have been thinking quite a lot this evening, and I shall have pleasure in supporting this Institution and its research plans in aiding it to bring Dr. Schlesinger into our Institution. For this purpose I am willing to give £25,000. If I may say so, we are always pleased to appreciate the abilities of any man from any part of the world, and I think it is one of the reasons we are such a great nation."

The gathering here this evening, with representatives from many different nations, is an example of the broad international outlook which our nation and our Institution continues to hold. I had the privilege, in my capacity as Chairman of Council and as Member of Council later, to meet Lord Nuffield on many occasions, and to have the opportunity of appreciating how his mind worked. He told me, on one occasion when he had made another gift relative to our Headquarters, that he always liked helping those who helped themselves. He equally knew that we were determined to go ahead in establishing a research centre. I would like to pay tribute to this great man who, in giving this gift, gave the first real impetus to the setting up of our research centre.

Many other important people and institutions, however, were at this time interested in the Institution's pioneering work. With the help of Dr. Schofield (by now a Member of the Institution) and the Board of Governors of Loughborough College, the Institution was permitted to have a portion of one of their laboratories to commence activities. It was on Monday, 2nd January, 1939, that Dr. Georg Schlesinger — following his appointment by our Institution as "Director of the Institution's Research Department" — commenced his work in our laboratory at Loughborough College.

It is interesting to note that the first abstracts from the technical press, including America, France and Germany, were edited by Dr. Schlesinger and distributed to our members in the February Journal, 1939 — 19 years ago.

No time was lost by our research centre in compiling basic information. One of the first Papers presented by Dr. Schlesinger, in his capacity as our Director of Research, was entitled "Cutting Tools". Other Papers followed, and the result of the first investigation and research of our centre was the report on "Surface Finish", issued by The Institution of Production Engineers in 1942. This Report still has considerable value today.

This was followed by:-

1. Practical Research in Production Engineering, 1938.
2. High Speed in War-time Production Shops, April, 1943.
3. Acceptance Test Charts for Machine Tools, first published in 1930 and added to later, in 1940 - 1942.
4. Practical Drilling Tests by Drs. Galloway and Morton in 1946, just before the formation of PERA.

Time does not permit me to tell you about many of the human aspects of the Institution's pioneering work in the formation of this first centre. I will leave it to your imagination to visualise the early discussions which took place between the somewhat old-fashioned members of the Institution, and others who, in greater numbers, could see the vital need, not only from the production engineering point of view, but

from the national point of view, for the setting up of research work. One happy continuation of this history which I have briefly recited to you is the connecting link carried on by Dr. D. F. Galloway, M.I.Prod.E., now the Director of PERA. He joined the Institution's Research Centre at Loughborough in November, 1939. He assisted Dr. Schlesinger in making the first important researches and subsequently issued his own reports. We are, of course, very happy to know that he is with us tonight.

I would once more like to say how keen The Institution of Production Engineers is to work in close association with the Production Engineering Research Association of Great Britain. It may be asked why the Institution, having set up the first centre, did not carry on entirely on its own. The chief reason for this was, of course, financial; we alone could not attract a grant from the Government through the Department of Scientific and Industrial Research.

Early in 1945, this Institution, The Machine Tool Trades Association, The Gauge and Tool Makers Association, and the National Federation of Engineers' Tool Manufacturers set up a committee, and following this the Department of Scientific and Industrial Research agreed to give financial assistance of £1 for every £1 subscribed by industry up to £15,000. The present figures are much higher, but not high enough.

**formation of PERA**

Therefore, in March, 1946, the Production Engineering Research Association of Great Britain was formed. It is interesting to note that the first four members representing The Institution of Production Engineers on the first Council of PERA included Dr. Schofield, and that out of 30 members of the PERA Council, there are 15 who are members of The Institution of Production Engineers, plus Dr. Galloway himself and Mr. R. Tilsley. I am happy to think that, being one of the pioneers of the original centre, I am now a Member of the PERA Council, but above all, we are delighted to know that Dr. Schofield is also a Member of the PERA Council today.

I trust that this brief factual review, recalling the pioneer work carried out by — at that time — a very young Institution, will be taken as an example to other pioneering activities which still lie before us, not only in the professional and scientific world, but specifically in the sphere of international relationship. The ability of the scientists of the world to find common ground has recently been exemplified by the agreement on control centres for atomic tests. I expect much of what has been said follows a similar pattern in countries all over the world, where groups of enthusiasts have stimulated the initial formation, not only of research centres, but the appreciation of research production engineering, leading to the very high standard of knowledge now available concerning this subject.

Any research into production, as I see it, must always involve the lives of people, not only those directly concerned, but all those who benefit as a result of an increasing distribution of goods and, therefore, at all times in our research work, must we think of the human aspects. If the result of the research into greater productivity leads to an increased distribution of life's necessities to the many millions of under-nourished peoples in the world, then increased production in its broadest sense will have justified its study.

Your Institution, which was formed in 1949 - 1950, decided to establish a common meeting ground on which scientists in the field of production technology could discuss their problems in a free atmosphere of trust and confidence. We sincerely hope that during your visit to our country you have found the necessary atmosphere for free and progressive discussion. Your Institution, I understand, has members from 14 different countries and you hold your annual conference in different parts of the world.

We are, of course, particularly pleased to see the ladies present here tonight. Apart from their charm and beauty, I firmly believe that ladies, in travelling, learn how other countries live whilst the men study, chiefly, how other countries work. If we are to have international understanding, then the question of how other nations live is just as important as how other nations work; therefore, I repeat a special welcome to the ladies here tonight.

May I, therefore, on behalf of The Institution of Production Engineers and the members of the Midlands Region, wish you well in your work and may the result of your researches lead to the benefit of mankind.

I am proud and happy to propose the toast of the International Congress for Production Engineering Research, and couple this toast with the name of your President, Professor E. Bickel.

---

Professor E. Bickel, of Switzerland, President of C.I.R.P., responded. In a witty and entertaining speech, Professor Bickel said how much the delegates had enjoyed their visit. Although they had been working very hard throughout the Conference, they had also had time to see something of Great Britain and to enjoy her hospitality. Professor Bickel mentioned that he himself had worked in Britain before the last War and, indeed, had been responsible for the introduction to this country of a well-known water heater.

He thanked Mr. Hancock and the other members of the Institution very warmly for the very enjoyable and friendly hospitality which the Institution had extended to them.

# news of members

**Mr. Leonard Baker,** Associate Member, has been appointed Deputy Managing Director of Coventry Gauge & Tool Co. Ltd. After distinguished service with the Royal Navy, Mr. Baker retired in 1948, with the rank of Commander (E) and has spent the subsequent 10 years in industry. He relinquishes his position with Hamworthy Engineering Company to take up this new appointment.

**Mr. J. L. Burbidge,** Associate Member, formerly with David Brown Industries Ltd., has taken up a new appointment as Works Director to The British Refrasil Co. Ltd., Stillington, Co. Durham.

**Mr. J. O. Garvie,** Associate Member, has relinquished his appointment of Production Superintendent, H. Frost & Co. Ltd., Walsall, and is now Planning Engineer to Jensen Motors Ltd., West Bromwich.

**Mr. H. T. Hill,** Associate Member, is now Chief Production Engineer at Blackburn & General Aircraft Ltd., Yorkshire.

**Mr. S. S. Jauhari,** Associate Member, until recently Assistant General of Ordnance Factories, has now taken up a new position as Superintendent, Ordnance Factory, Kanpur. This transfer has necessitated Mr. Jauhari's resignation from the Calcutta Section Committee, of which he was an extremely active member.

**Mr. R. Nash,** Associate Member, has taken up an appointment as a Programme Planning Engineer on Numerical Control with the Boeing Aeroplane Company, of Seattle, U.S.A.

**Mr. Donald G. Petch,** Associate Member, has been promoted Lecturer in Production Engineering at the North-East Essex Technical College and School of Art, Colchester.

**Mr. P. S. Pickles,** Associate Member, has relinquished his position of Lecturer in Metrology and Machine Tools with the Mid-Cheshire College of Further Education, and is now Head of Engineering and Building Departments at the Macclesfield College of Further Education.

**Mr. Kenneth F. Whitton,** Graduate, has relinquished his position as Methods Engineer with British General Electric Co. Pty. Ltd., Auburn, New South Wales, and has taken up an appointment as Production Engineer with S. Smith & Son (Australia) Pty. Ltd., South Granville, New South Wales.

**Mr. A. F. D'Souza,** Graduate, has been awarded a Fellowship to study for the Master of Science degree at the University of Notre Dame, Indiana, U.S.A., and he has accordingly relinquished his appointment with Ransomes & Rapier Ltd., Ipswich.

## THE PRESIDENT AT READING

**On 18th September, 1958, the President of the Institution, The Rt. Hon. The Earl of Halsbury, F.R.I.C., F.Inst.P., M.I.Prod.E., addressed a meeting of the Southern Region of the Institution, arranged by the Reading Section, at the Great Western Hotel, Reading. Lord Halsbury's subject was " Technology and Humanism ".**

**This photograph, taken during the meeting, shows on Lord Halsbury's right, Mr. H. P. Mott, Chairman of the Reading Section, and The Rt. Worshipful The Mayor of Reading (Councillor E. Busby, J.P.), who opened the proceedings. On Lord Halsbury's left is Mr. H. W. Bowen, O.B.E., Chairman of the Institution's Council.**

# Hazleton Memorial Library

## ADDITIONS

Association of Bronze and Brass Founders, Birmingham. **"Costing a Casting."** 2 volumes. *Birmingham, the Association,* 1958. *Vol.* 1 — 16 *pages, diagrams. Vol.* 2 — 15 *specimen forms.*

These books were published in response to a request for information on costing made by members of the Association not large enough to employ specialised costing staff. At least three out of four bronze and brass foundries in this country have less than 20 employees, and the system described is intended for use in foundries with a labour force of up to 50. The book starts by showing how to estimate and describes a simple system of booking labour costs and recording other expenses. Contents: *Volume* 1. Introduction — Available foundry information and its uses — The estimate sheet — Metal — Labour — Overheads — Despatch — Melting cost — Estimate sheet as cost sheet — Routing of costing a casting. *Volume* 2. Specimen forms.

Carter, C. F., and Williams, B. R. **"Investment in Innovation."** *London, etc., O.U.P.,* 1958. 167 *pages.* 15s.

"The term 'investment' . . . refers to the spending of money on the plant, machines and buildings of industry, and on vehicles and other transport facilities . . . This book is a study of part of the subject which arises out of the work of the Science and Industry Committee. The Committee was appointed by the Royal Society of Arts, the British Association for the Advancement of Science and by the Nuffield Foundation to investigate factors influencing the rate of adoption of new scientific and technical ideas by British industry . . ." The authors' first report *Industry and Technical Progress* was published in 1957, and reviewed in the Journal of October, 1957. In the course of investigations the Board of Trade suggested that the authors might make a subsidiary report on "materials which could contribute to knowledge of the background of investment decisions", and this report presents the results of their investigations. The book uses much of the material obtained by industrial studies for the earlier book to examine the features affecting industrialists in investing money in new plant and equipment. Contents: Why study investment? — The technical opportunity to invest — The problem of uncertainty — The variety of business motives — The grounds for deciding to invest — On not investing — Predictions true and false — Some examples from the case studies — Summary and implications — Appendix: traditional ideas for the decision process.

Cemach, Harry P. **"Work Study in the Office."** *London, Current Affairs Ltd.,* 1958. 166 *pages. Illustrated. Diagrams.* 25s. An Office Magazine publication.

The author believes that "the work study approach of systematic investigation and scientific analysis" is the only way to improve office productivity. This book is an introductory manual of what is generally called "O. and M.", but the author stresses that there is no essential difference between work study and O. and M., and that there is no reason why the refined techniques of work study used in production work should not eventually be used in clerical work. He briefly describes the standard methods of work measurement and method study. He does not pretend to make a work study expert of his reader, but his book should help office workers to develop the "work study approach", or at least make them realise that such a systematic analytical approach to their problems is possible, enable them to recognise their problems, and to co-operate intelligently with the work study expert should one be needed.

Eminger, Z., and Koselev, V. **"Cast Tools."** *Prague, Artia; London, Constable,* 1958. 230 *pages. Illustrated. Diagrams.* £1.

This book presents the results of experimental work undertaken to work out a production process for the casting of high speed steel tools which would be simple and could be operated without special equipment. Contents: A survey of the properties of steel — Comparison of cast and forged steel — Tool casting — Production methods in tool casting — High speed steels — Heat treatment, machining, and service results of cast tools. Cost finding considerations — Theoretical analysis of heat treatment and the structural analysis of cast tools.

Eschmann, Hasbargen and Wiegand. **"Ball and Roller Bearings: Their Theory, Design and Application."** *London, K. G. Heyden and Co.,* 1958. 375 *pages.* Two supplements in pocket: Load ratings of ball and roller bearings; Conversion tables.

This book is intended to provide the detailed knowledge of anti-friction bearing technology which is necessary to the designer. The types, materials, dimensions and tolerances of the most important bearings manufactured in Europe are discussed initially. The subsequent theoretical section of the book is arranged so that a consideration of bearing stressing and kinematic phenomena precedes a discussion of the basic relationships between carrying capacity, load and life. The task which the bearings must fulfil is then discussed, and in a final section examples are given of bearing applications to illustrate from which aspects the best solution of a bearing problem may be obtained. The contents of the book are based on designs, specifications and standards used in Germany. The essential data of these provisions are contained in the tables. The metric system has been retained and conversion tables added to facilitate reading. Contents: Types of ball and roller bearings — Bearing calculations — Basic principles for the design of bearing arrangements — Design of bearing locations — Bearing failures — Examples of calculations and design of ball and roller bearings. Supplements: Load ratings of ball and roller bearings; Conversion tables.

Féderation des Industries Mecaniques et Transformatirces des Metaux, Paris. **"Les Industries Mecaniques Francaises."** *Paris, the Federation,* 1958. 279 *pages. Illustrated. Diagrams.*

A survey with statistics of the French engineering industry. Includes a list of trade associations. In French, English and Spanish.

Hannah, John, and Stephens, R. C. **"Mechanics of Machines: Elementary Theory and Examples."** *London, Edward Arnold (Publishers) Ltd.,* 1958. 238 *pages. Diagrams.* 18s.

Suitable for first year engineering degree and National Diploma students, and for H.N.C. students of equivalent standard. Emphasis has been given to the chapter on general dynamics, since, although a knowledge of the basic principles is usually assumed, these principles form the basis of the more advanced topics in Mechanics of Machines. Questions and answers are given from the examination papers of the Universities of London and The Institution of Mechanical Engineers.

# Lubrication Plus Protection

*Mobilux Grease* is a lithium-base lubricant of excellent structural stability and purity. It is a new, general-purpose grease superseding conventional greases. It provides effective lubrication for the majority of grease applications over a temperature range from minus 20°F to 250°F. It is exceptionally resistant to water washing and contains special additives to prevent rust formation. Both in the laboratory and in the field Mobilux Grease has proved its outstanding efficiency as a lubricant and protector.

## MOBILUX GREASE

Mobil

MOBIL INDUSTRIAL LUBRICANTS

## BRITAIN'S FIRST BRILLIANT Polyester

*Here is a great new advance in wood finishing—and in full scale production use too! Every Sobell and McMichael T.V. set is now protected and enhanced by the brilliant new R.I.C. Polyester 2495. This superb hard-gloss surface is mar-proof, heat and acid resistant, gives a lasting brilliance that means greater customer appeal.*

*Apart from enhancing the product, this remarkable R.I.C. Polyester is very much a commercial proposition. It's produced in Britain, so costs are reduced — it protects your products in transport and storage — it reduces fire risks — it enables you to produce to a uniform quality at greater speed.*

*Today R.I.C. offer you Polyesters of the highest quality, accepted by the trade, backed by extensive production line experience. Our Technical Advisory Service is at your disposal.*

**RIC** **POLYESTER 2495**

ROBT. INGHAM CLARK & CO., WESTMORLAND HOUSE, 127/131 REGENT STREET, LONDON, W.1. Telephone: REGENT 0831

# The Council of the Institution

1958/1959

---

**President**

The Rt. Hon. The Earl of Halsbury, F.R.I.C., F.Inst.P.

**Vice-Presidents**

J. E. Hill G. R. Pryor

**Chairman of Council**

H. W. Bowen, O.B.E.

**Vice-Chairman of Council**

R. H. S. Turner

**Immediate Past Chairman of Council**

H G. Gregory

**Past Presidents**

Major-General K. C. Appleyard, C.B.E. Sir George Bailey, C.B.E. E. W. Hancock, O.B.E. Sir Leonard Lord, K.B.E.
The Rt. Hon. Viscount Nuffield, C.H., G.B.E. Sir Walter Puckey Norman Rowbotham, C.B.E. J. D. Scaife
Dr. H. Schofield, C.B.E. The Rt. Hon. The Lord Sempill, A.F.C. Sir Cecil Weir, K.C.M.G., K.B.E., D.L., M.C.

**Presidents of Councils outside the United Kingdom**

AUSTRALIAN COUNCIL — W. Gwinnett
SOUTH AFRICAN COUNCIL — T. H. Hunter

**Chairmen of Regional Committees**

**East & West Ridings**
I. G. Hopkinson
**Eastern**
K. S. Jewson
**Midlands**
H. Tomlinson
**North Midlands**
L. Shenton
**Northern**
N. E. Langdale
**North Western**
T. A. Stoddart
**Northern Ireland**
E. A. Patston
**Scotland**
R. W. Mackay
**South Eastern**
A. L. Stuchbery
**Southern**
H. P. Mott
**South Western**
S. G. E. Nash
**Wales**
H. G. H. Dixon

**Additional Representatives on Council**

**East & West Ridings**
A. E. Clifford
**Midlands**
T. W. Elkington
**North Western**
J. H. Winskill
**South Eastern**
J. L. Gwyther

**Chairmen of Standing Committees**

B. E. Stokes (*Editorial*) B. G. L. Jackman (*Research*) F. C. Cooke (*Papers*) L. W. Bailey (*Library*) J. France (*Education*) R. E. Mills (*Standards*) K. J. Hume (*Membership*)

**Elected Members**

H. Bainbridge G. V. Bevan G. R. Blakely J. V. Connolly E. Percy Edwards L. R. Evans P. H. W. Everitt
E F. Gilberthope F. Grimshaw, O.B.E. H. B. Harris B. C. Harrison R. E. Leakey E. Levesley R. N. Marland
Dr. T. U. Matthew L. S. Pitteway R. H. S. Turner R. J. C. Whitaker

**Chairmen of Sections outside the United Kingdom where Councils are not established**

**Bombay**
P. V. Shah
**Canada**
S. S. Pritchard
**Calcutta**
T. R. Gupta
**New Zealand**
H. K. Pickering

# Overseas Councils

## AUSTRALIA

**President**
W. Gwinnett

**Chairman**
J. M. Steer

| Immediate Past President | Vice-Chairman | Honorary Secretary | Honorary Treasurer |
|---|---|---|---|
| J. N. Kirby, O.B.E. | C. S. Curtis | L. W. Worthington | K. Slorach |

**Delegates**

R. E. Andrews H. J. Baker J. G. Brookman R. W. Deutsher S. Downie N. L. Eaton N. A. Esserman P. E. Frye C. A. Gladman B. H. M. Coombes E. J. W. Herbert A. G. Jones A. E. Newcombe F. W. Penny C. Pullen

## SOUTH AFRICA

| President | 1st Vice-President | 2nd Vice-President |
|---|---|---|
| T. H. Hunter | C. J. Mogford | D. A. Petrie |

**Past Presidents**

A. B. Anderson R. H. Arbuckle L. H. L. Badham D. N. S. Clare W. G. Gillespie H. J. G. Goyns J. Henry D. Lion-Cachet J. Renwick D. E. Hamm

**Elected Members**

A. B. Anderson G. T. Chawner E. H. Dallas P. C. Ellett D. A. Horton G. K. Melvill G. G. Tardrew H. H. Waters F. Westall

## REGIONAL HONORARY SECRETARIES

| | | | |
|---|---|---|---|
| **East & West Ridings** | C. W. Overin | **Northern Ireland** ... ... | J. G. Easterbrook |
| **Eastern** ... ... | A. B. Brook | **Scotland** ... ... ... | J. Nicolson Low |
| **Midlands** ... ... ... | A. C. Turner | **South Eastern** ... ... | J Aikman |
| **North Midlands** ... ... | C. N. T. Manfull | **Southern** ... ... ... | J. W. Taylor |
| **Northern** ... ... ... | A. Smith | **South Western** ... ... | A. Eustace |
| **North Western** ... ... | J. P. Speakman | **Wales** ... ... ... | C. Ll. Griffiths |

## SECTION CHAIRMEN

F. W. Penny ..... *Adelaide*
R. N. Marland ..... *Birmingham*
P. V. Shah ..... *Bombay*
T. R. Gupta ..... *Calcutta*
S. S. Pritchard ..... *Canada*
H. G. H. Dixon ..... *Cardiff*
W. C. Hosken ..... *Cornwall*
V. W. Oubridge ..... *Coventry*
J. Smedley ..... *Derby*
C. F. Rose ..... *Doncaster*
R. W. Mackay ..... *Dundee*
P. H. Lee ..... *Edinburgh*
G V. Stabler ..... *Glasgow*
A. J. Lissaman ..... *Gloucester*
A. E. Clifford ..... *Halifax & Huddersfield*
L. A. Childs ..... *Ipswich & Colchester*
R. Shilton ..... *Leeds*
R. M. Evans ..... *Leicester*
J. Cunningham, M.B.E. ..... *Lincoln*
H. Mason ..... *Liverpool*
G. A. J. Witton ..... *London*
J L. Gwyther ..... *Luton*
F. W. Cranmer ..... *Manchester*
J. M. Steer ..... *Melbourne*
H. K. Pickering ..... *New Zealand*
A. Cameron ..... *Newcastle upon Tyne*
E. A. Patston ..... *Northern Ireland*
R. E. Copelin ..... *Norwich*
B. A. Green ..... *Nottingham*
L. P. Coombes ..... *Oxford*
H. B. Harris ..... *Peterborough*
W. L. Jones ..... *Preston*
H. P. Mott ..... *Reading*
W. Robinson ..... *Rochester*
F. Woodifield ..... *Sheffield*
W. Castledine ..... *Shrewsbury*
D. E. Hamm ..... *South Africa*
E. S. Hammett ..... *South Essex*
J. S. Hopkinson ..... *Swansea*
J. B. Turner ..... *Southampton*
A. McDonald ..... *Stoke-on-Trent*
S. Downie ..... *Sydney*
N. E. Langdale ..... *Tees-Side*
S. G. E. Nash ..... *Western*
P. J. Shipton ..... *Wolverhampton*
J. D. Nicholls ..... *Worcester*

## GRADUATE SECTION CHAIRMEN

D. J. White ..... *Birmingham Graduate*
B. Brewster ..... *Coventry Graduate*
H. Scholes ..... *Halifax & Huddersfield Graduate*
J. Keightley ..... *Leeds Graduate*
G. L. Smith ..... *Liverpool Graduate*
P. Trosset ..... *London Graduate*
R. H. Cannon ..... *Luton Graduate*
R. C. Yarnell ..... *Manchester Graduate*
F. A. Roberts ..... *Melbourne Graduate*
H. E. A. Noble ..... *Newcastle upon Tyne Graduate*
P. M. Goodchild ..... *Rochester Graduate*
D. R. Wilson ..... *Sheffield Graduate*
T. G. Mossman ..... *Western Graduate*
P. F. W. Guest ..... *Wolverhampton Graduate*

## SECTION HONORARY SECRETARIES

### AUSTRALIA

| | |
|---|---|
| **Adelaide (South Australia) ...** | B. H. M. Coombes, 11 Elmo Avenue, Westbourne Park, Adelaide, Australia. |
| **Melbourne (Victoria, Australia)** | R. W. Deutsher, 374 Nepean Highway, Brighton, Victoria, Australia. |
| **Melbourne Graduate (Victoria Australia) ... ... ...** | H. B. Davies, 77 Longview Road, North Balwyn, Victoria, Australia. |
| **Sydney (New South Wales) ...** | K. G. Slorach, 34 Anderson Avenue, Ryde, New South Wales, Australia. |

### CANADA

| | |
|---|---|
| **Canada ... ... ...** | Frank R. Taylor, 1 Cheritan Avenue, Apt. 110, Toronto 12, Ontario, Canada. |

### INDIA

| | |
|---|---|
| **Bombay ... ... ...** | C. R. Pal, The Crescent Iron & Steel Works Ltd., Goregaon (East), Bombay, S.D., India |
| **Calcutta ... ... ...** | P. J. O'Leary, c/o Guest, Keen, Williams Ltd., 41 Chowringhee Road, Calcutta, India |

### NEW ZEALAND

| | |
|---|---|
| **New Zealand ... ...** | G. Stedman, 3 Harrison Avenue, Belmont, Takapuna, Auckland, New Zealand. |

### SOUTH AFRICA

| | |
|---|---|
| **South Africa ... ... ...** | A. Aitken, 209-211 Pharmacy House, 80 Jorissen Street, Johannesburg, P.O. Box 10837, South Africa. |

### UNITED KINGDOM

| | |
|---|---|
| **Birmingham ... ... ...** | H. W. White, "Spring Pools", 677 Birmingham Road, Lydiate Ash, Bromsgrove, Worcs. |
| **Cardiff ... ... ...** | C. Ll. Griffiths, "Brynteg", 139 Tyntyla Road, Llwynypia, Rhondda, Glamorgan. |
| **Cornwall ... ... ...** | F. G. Hawke, 3 Bellevue Terrace, East Hill, Tuckingmill, Camborne, Cornwall. |
| **Coventry ... ... ...** | A. S. Hopkins, 39 Oaks Road, Kenilworth, Warwicks. |
| **Derby ... ... ...** | P. Warburton, 16 Vicarage Road, Chellaston, Derby. |
| **Doncaster ... ... ...** | G. R. Wimpenny, 16 Tickhill Square, Denaby Main, Doncaster. |
| **Dundee ... ... ...** | J. Nicolson Low, Technical College, Bell Street, Dundee. |
| **Edinburgh ... ... ...** | A. S. Wilson, Ferranti Ltd. (Laboratory Workshop), Ferry Row, Edinburgh, 5. |
| **Glasgow ... ... ...** | W. H. Marley, G. & J. Weir Ltd., Cathcart, Glasgow, S.4. |
| **Gloucester ... ... ...** | B. E. Gwynne Clarke, "Chez-Nous", Okus Road, Charlton Kings, Cheltenham. |
| **Halifax & Huddersfield ...** | C. W. Overin, 353 Whitehall Road, Westfield, Wyke, near Bradford, Yorks. |
| **Ipswich & Colchester ...** | H. F. Harker, Ransomes, Sims & Jefferies Ltd., Orwell Works, Ipswich. |
| **Leeds ... ... ...** | J. L. Townend, 26 Moor Allerton Drive, Street Lane, Leeds, 17. |
| **Leicester & District ... ...** | E. G. Davis, 19 Festival Avenue, Humberstone Lane, Thurmaston, Leics. |
| **Lincoln ... ... ...** | H. Wright, 101 Longdales Road, Lincoln. |
| **Liverpool ... ... ...** | (Acting) H. Mason, 51 Stairhaven Road, Liverpool, 19. |
| **London ... ... ...** | R. J. C. Whitaker, The Glacier Metal Co. Ltd., Ealing Road, Alperton, Middlesex. |
| **Luton ... ... ...** | J. F. W. Galyer, Engineering Department, Luton & South Bedfordshire College of Further Education, Park Square, Luton, Bedfordshire. |
| **Manchester ... ... ...** | J. P. Speakman, 223 Douglas Road, Atherton, near Manchester. |
| **Newcastle upon Tyne ...** | A. C. Foskew, 35 Oakwood Avenue, Low Fell, Gateshead, 9. |
| **Northern Ireland ... ...** | J. G. Easterbrook, "Hilleen", 22 Ascot Park, Knock, Belfast. |
| **Norwich ... ... ...** | J. I. Hilder, 2a Gorse Road, Thorpe, Norwich. |
| **Nottingham ... ... ...** | K. Liquorish, 28 Mona Street, Beeston, Nottingham. |
| **Oxford ... ... ...** | F. S. Chappell, 58 Lancut Road, Witney, Oxfordshire. |
| **Peterborough ... ...** | N. Holmes, "Arncliffe", 11 Mary Armyn Road, Orton Longueville, Peterborough. |
| **Preston ... ... ...** | W. H. Preston, 25 Clifton Avenue, Leyland, Lancashire. |
| **Reading ... ... ...** | R. W. H. Mark, "The Beeches", 41 Reading Road, Woodley, Berkshire. |
| **Rochester & District ...** | W. G. Clements, 11 Charing Road, Gillingham, Kent. |
| **Sheffield ... ... ...** | T. F. Newton, c/o E. Pryor & Son Ltd., West End Works, Broom Street, Sheffield, 10 |
| **Shrewsbury ... ... ...** | W. M. Buchan, Llanberis, 36 Mytton Oak Road, Shrewsbury. |
| **Southampton ... ...** | J. W. Taylor, 44 Deacon Road, Bitterne, Southampton. |
| **South Essex ... ... ...** | F. Hopkinson, "Woodley", 40 Highfield Road, Chelmsford, Essex. |
| **Swansea ... ... ...** | C. L. Clarke, 11 Alder Road, Cimla, Neath, South Wales. |
| **Stoke-on-Trent ... ...** | E. J. Averill, "Berry Dale", 87 Hunters Way, Penkhull, Stoke-on-Trent. |
| **Tees-Side ... ... ...** | J. H. Cooper, 48 Hob Hill Close, Saltburn-by-the-Sea, Yorkshire. |
| **Western ... ... ...** | A. Eustace, 19 Ferndale Road Northville, Bristol, 7. |
| **Wolverhampton ... ...** | W. T. Vaughan, "Windsor", 24 Windermere Road, Palmers Cross, Tettenhall, Staffs. |
| **Worcester ... ... ...** | R. Wheeler, Old Farm House, 7 Parish Hill, Bournheath, near Bromsgrove, Worcestershire. |

## CORRESPONDING MEMBER IN MIDDLE EAST

J. Merkine, 45 Arlozoroff Street, Ramat-Gan, Israel.

## CORRESPONDING MEMBER IN WEST AFRICA

H. P. Halfter, Gold Coast Railways & Harbour Admin.,
P.O. Box 202, Takoradi, Ghana, West Africa.

## GRADUATE SECTION HONORARY SECRETARIES

| | |
|---|---|
| **Birmingham** ... ... ... | R. V. Whately, c/o 130 Church Road, Moseley, Birmingham, 13. |
| **Coventry** ... ... ... | E. R. S. Marrs, 15 Montrose Avenue, Lillington, Leamington Spa. |
| **Halifax & Huddersfield** ... | G. Wilde, 56 Milton Avenue, Albert Road, Sowerby Bridge, near Halifax. |
| **Leeds** ... ... ... | T. Robinson, 764 York Road, Leeds, 15. |
| **Liverpool** ... ... ... | M. Green, 1 Parkview Road, Croxteth, Liverpool, 11. |
| **London** ... ... ... | R. S. Nicholas, 111 Falconwood, Addington, Croydon, Surrey. |
| **Luton** ... ... ... | W. M. Stern, 37 Rossfold Road, Sundon Park, Luton, Bedfordshire. |
| **Manchester** ... ... ... | R. A. Jones, 33 Kirkham Road, Heald Green, Cheshire. |
| **Newcastle upon Tyne** ... | P. G. Jenkins, 25 Windsor Road, Whitley Bay, Northumberland. |
| **Rochester & District** ... | J. R. Anderson, 63 Watling Street, Strood, Rochester, Kent. |
| **Sheffield** ... ... ... | E. Willcox, Ellis, Son, & Paramore Ltd., Spring Street Works, Sheffield, 3 |
| **Western** ... ... ... | R. E. Everhard, 25 Boverton Road, Filton, Bristol. |
| **Wolverhampton** ... ... | T. J. Harrison, " The Dingle ", Planks Lane, Wombourn, Staffordshire. |

## LOUGHBOROUGH COLLEGE STUDENT SECTION

*Chairman*:
M. C. Fryer, Dept. of Industrial Engineering, College of Technology, Loughborough, Leics.

*Honorary Secretary*:
J. Fairbrother, 27 Eaton Road, Ilkley, Yorkshire.

## MATERIALS HANDLING GROUP

*Chairman*:
A. G. Hayek, A G. Hayek and Partners Ltd., Federation House, Stoke-on-Trent.

*Secretary*:
I. B. King, Assistant Education and Technical Officer, 10 Chesterfield Street, London, W.1.

## EDUCATION DISCUSSION GROUPS

### London Centre

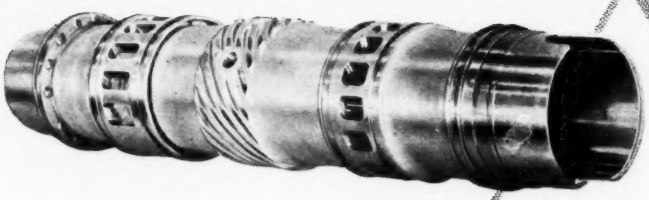
*Chairman*:
R A. Bartholomew, 23 Well Lane, Galleywood, near Chelmsford, Essex.

*Honorary Secretary*:
D. R C. Holmes, 35 Sandringham Drive, Ashford, Middlesex.

### Midland Centre

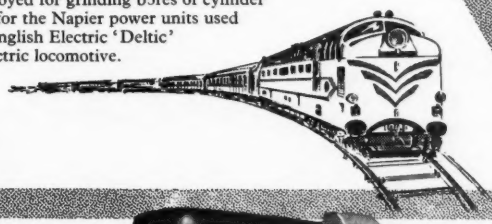
*Chairman*:
W. L. Jackson, Senior Lecturer in Production Engineering, Chance Technical College, Smethwick.

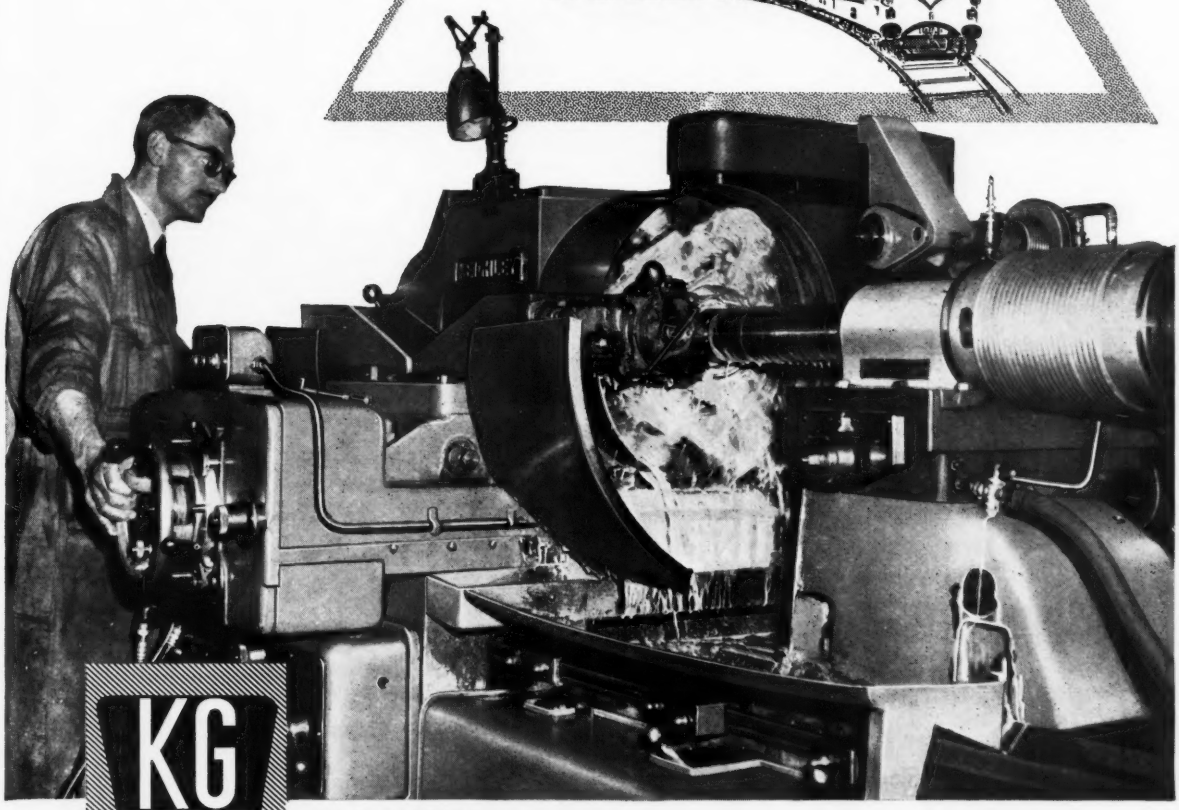
*Honorary Secretary*:
N. Ward, 88 Sutton Oak Road, Streetly, Sutton Coldfield.



# *precision made for constant service*

Typical of special purpose grinding machines built to customers' requirements for modern production methods, this Keighley heavy duty double-head internal grinder is one of a series with an outstanding record of reliability and steadily maintained accuracy installed by D. Napier & Son Ltd., Liverpool. Designed to meet exacting standards of precision combined with production economy, the machine is employed for grinding bores of cylinder liners for the Napier power units used in the English Electric 'Deltic' diesel-electric locomotive.





**KG** MACHINE TOOLS

***MANUFACTURE*** a comprehensive range of precision cylindrical, internal and universal grinders and build special purpose machines

KEIGHLEY GRINDERS (MACHINE TOOLS) LTD KEIGHLEY

ONE OF THE NEWALL GROUP

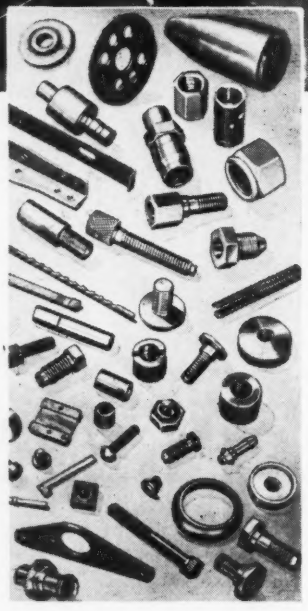
*Sales Organisation:*

**NEWALL GROUP SALES LTD PETERBOROUGH**

TELEPHONE: PETERBOROUGH 3227 OR KEIGHLEY 4294

P.1838

# DAWSON ROTARY DRUM MACHINES



Dawson Rotary Drum Machines handle large quantities of small machined parts and are made in four sizes to deal with quantities up to 7, 10, 15 or 25 cwts. an hour.

Operation is completely automatic and an electric skip hoist with vibrator feed is available to facilitate loading. The smallest machine in the range, size '00', is shown above, and the compact design and small amount of floor space required can be appreciated from the illustration.

These Dawson machines are ideal for the automatic cleaning of parts prior to metal finishing. Other Dawson machines operate on the conveyor system for flow-line cleaning of larger components and there are Ultrasonic Cleaners for the superfine cleaning of intricate parts.

*Write today for details of Dawson Automatic Cleaning Machines and mention the type of application in which you are interested.*

*Sales & Service for . . .* **DRUMMOND-ASQUITH** *. . . the British Isles*

DRUMMOND-ASQUITH (SALES) LTD., KING EDWARD HOUSE, NEW ST., BIRMINGHAM

*'Phone: Midland 3431 (7 lines) Grams: Maxishape, Birmingham. Also at LONDON: 'Phone: Trafalgar 7224 (5 lines) and GLASGOW: 'Phone Central 0922*

HF 265

ASQUITH

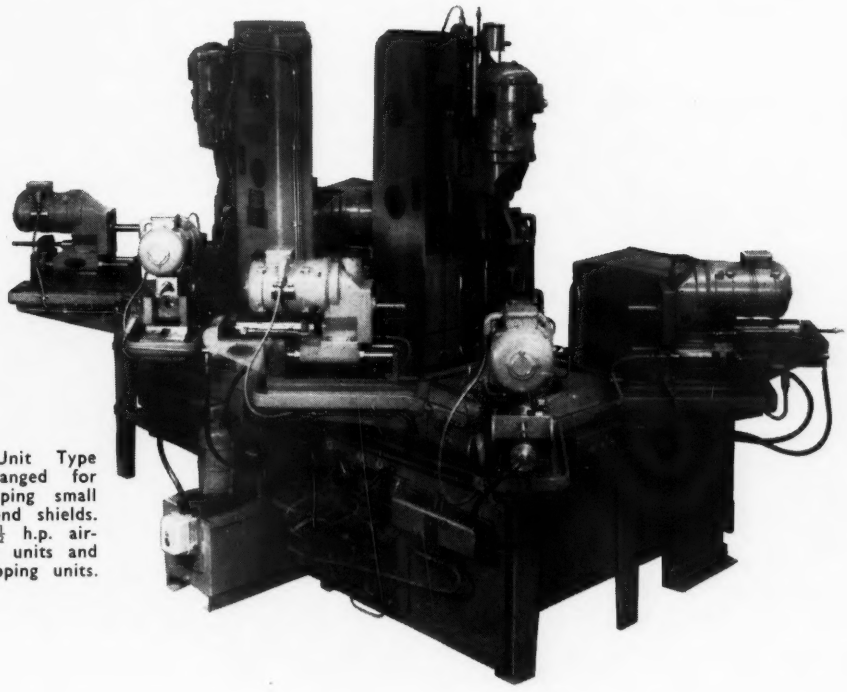
# UNIT TYPE MACHINES

## *fully engineered for high-output production*

Asquith Units from ½ h.p. upwards can be arranged as individual, multi-way, rotary transfer and in-line transfer machines for fast, automatic production. Some of the unit heads available are shown below. If you require large-quantity production of components at present produced on several machines, it will be worth investigating the possibility of machining them on an Asquith Unit Type Machine. Write today for details of the range of unit equipment or ask for a specialist to discuss your problem.

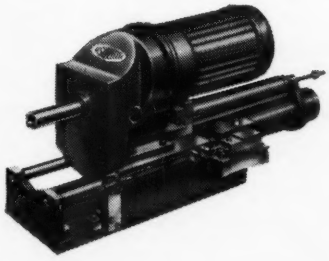
**WILLIAM ASQUITH LTD.**

**HALIFAX · ENGLAND**

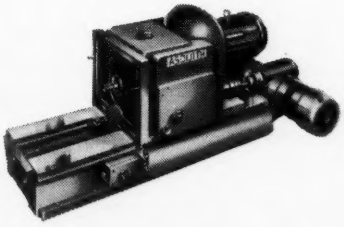


This Asquith Unit Type Machine is arranged for drilling and tapping small electric motor end shields. It incorporates ½ h.p. air-hydraulic drilling units and ½ h.p. screw tapping units.

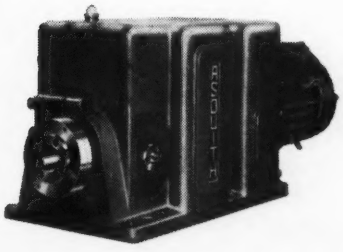
½ h.p. AIR HYDRAULIC DRILLING UNIT



3/5 h.p. SCREW FEED UNIT



HORIZONTAL STATIC MILLING UNIT



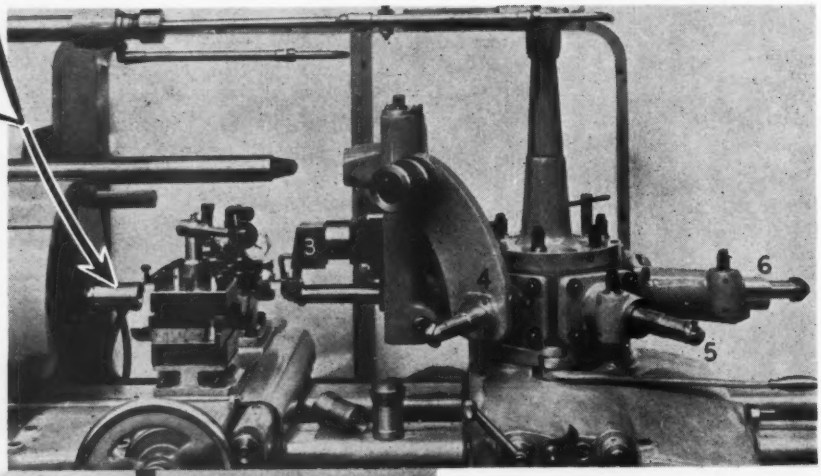
*Sales & Service for . . .* **DRUMMOND-ASQUITH** *. . . the British Isles*

DRUMMOND-ASQUITH (SALES) LTD., KING EDWARD HOUSE, NEW ST., BIRMINGHAM

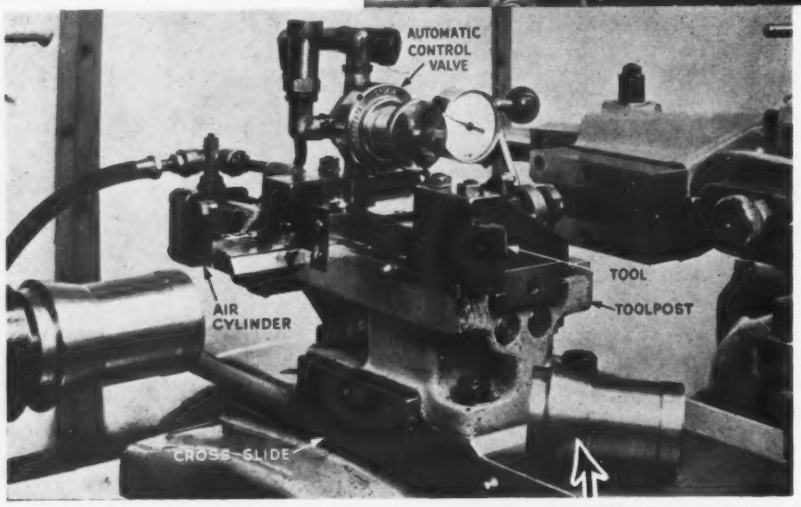
*'Phone: Midland 3431 (7 lines) Grams: Maxishape, Birmingham. Also at LONDON: 'Phone: Trafalgar 7224 (5 lines) and GLASGOW: 'Phone Central 0922*

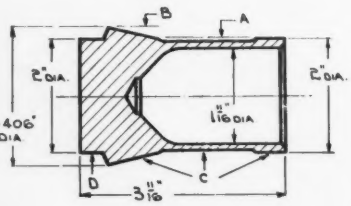
# *Maximum Production Special Tool Layouts*

SPRING COLLET BLANKS




## Ward No. 7 PRELECTOR




2 5/16 in dia. ·75 Carbon Steel, En.42. Tungsten Carbide and H.S. Steel Cutting Tools

**LATHE**

Fitted with 12in Tudor 3-Jaw Chuck

Floor-to-Floor Time

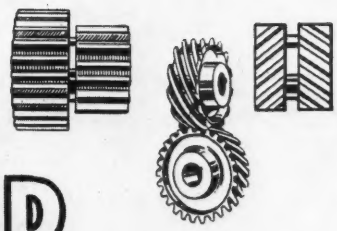
12 mins. each.

| DESCRIPTION OF OPERATION | Tool Position | | Spindle Speed R.P.M. | Surface Speed Ft. per Min. | Feed Cuts per inch |
|---|---|---|---|---|---|
| | Hex. Turret | Cross-slide | | | |
| 1. Feed to Stop and Start Drill | 1 | — | 350 | — | Hand |
| 2. Support and Rough Form Taper | 2 | Front 1 | 100 | 66 | Hand |
| Rough Form Head | — | Front 2 | 100 | 66 | Hand |
| Drill and Rough Knee Turn 2" dia. | 3 | — | 200 | 161 | 266 |
| 4. Finish Turn and Face D | — | Front 3 | 700 | 440 | Hand |
| 5. Profile Turn C (Copy Attachment) | 6 | Rear | 700 | 440 | 186 |
| 6. Rough Bore Bottom | 4 | — | 170 | 75 | Hand |
| 7. Microbore 1 11/16" dia. | 5 | — | 1000 | 442 | 266 |
| 8. Finish Bore Bottom, Face and Chamfer | 6 | — | 70 | 30 | Hand |
| 9. Part Off | — | Front 4 | 240 | 126 | Hand |

H·W·WARD & CO LTD
SELLY OAK
BIRMINGHAM 29
TELEPHONE SELLY OAK 1131
BRITISH MACHINE TOOL MAKERS ASSOC. LTD

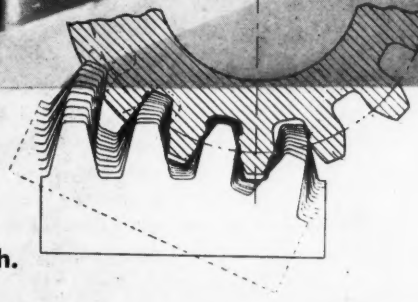
W657

**FOR SPUR, SPIRAL & DOUBLE HELICAL GEARS.**



# SUNDERLAND

## GEAR PLANERS



*The 'Sunderland' System Provides*

- **Extreme Simplicity and Mathematical Accuracy.**
- **Rapid output and Excellent Quality.**
- **Few Cutters and Great Range and Capacity.**
- **One Cutter Cuts any Number of Teeth of a Pitch.**
- **Low Initial Outlay on Cutters.**
- **Low Cost of Maintenance.**

## J PARKINSON & SON (SHIPLEY) LTD

SHIPLEY YORKSHIRE

TELEPHONE 53231

ASSOC. BRITISH MACHINE TOOL MAKERS LTD.

***Standard Sunderland Cutters now available from stock***

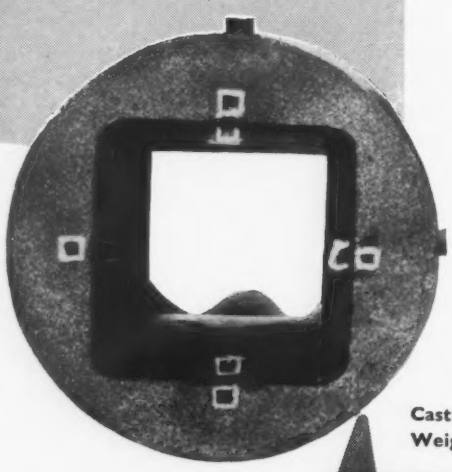
P373-B

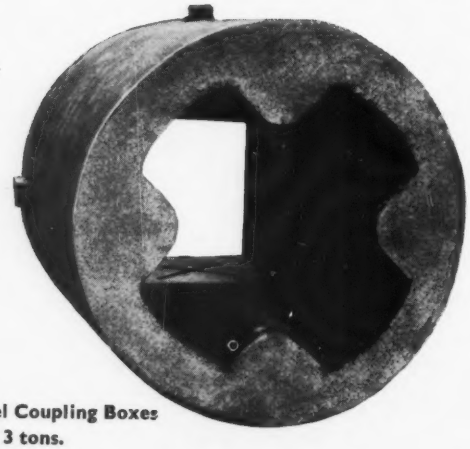
**Small and Intricate . . .**

**or**

**RUGGED and HEAVY . . .**

Cast Steel Lever
Weight : 20 lb





Cast Steel Coupling Boxes
Weight : 3 tons.

*you get a good job from the*

# EDGAR ALLEN STEEL FOUNDRY

These castings are all products of the Edgar Allen Steel Foundry, fully equipped to produce steel castings of any size, any shape, any quantity from 3 ounces to 14 tons, in carbon, special alloy, and manganese steels. We undertake, if necessary, every stage of the work from pattern-making right through to machining the finished job. This well-equipped foundry makes steel by the Converter and Electric Melting processes, as may be most suitable for the job in hand.
Fill in the request form below, and we'll gladly send you our "Steel Foundry Book" which tells you more about the all-round service we provide in steel castings.

**Edgar Allen & Co. Limited**
IMPERIAL STEEL WORKS · SHEFFIELD · 9

*For this Booklet post the coupon to-day*

To EDGAR ALLEN & CO. LTD. IPE/SC17
SHEFFIELD 9

Please send "Steel Foundry Book" to :

Name .....
Position .....
Firm .....
Address .....

# The Right Angle on the Drive

E.N.V. have exceptional facilities for the manufacture of spiral bevel and hypoid gears in sizes up to 72″, and for the serial production of right angle drive units for a wide variety of industrial applications.

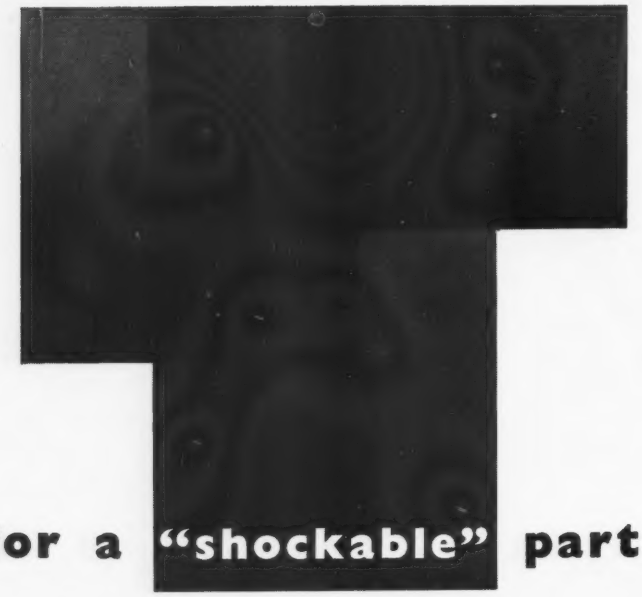
Engineers who need right angle transmissions are invited to communicate with the E.N.V. Design Department at the project stage.

**ENV** *for Gears*

**E.N.V. ENGINEERING COMPANY LIMITED** · HYTHE ROAD · WILLESDEN · LONDON N.W.10

Telephone: LADbroke 3622

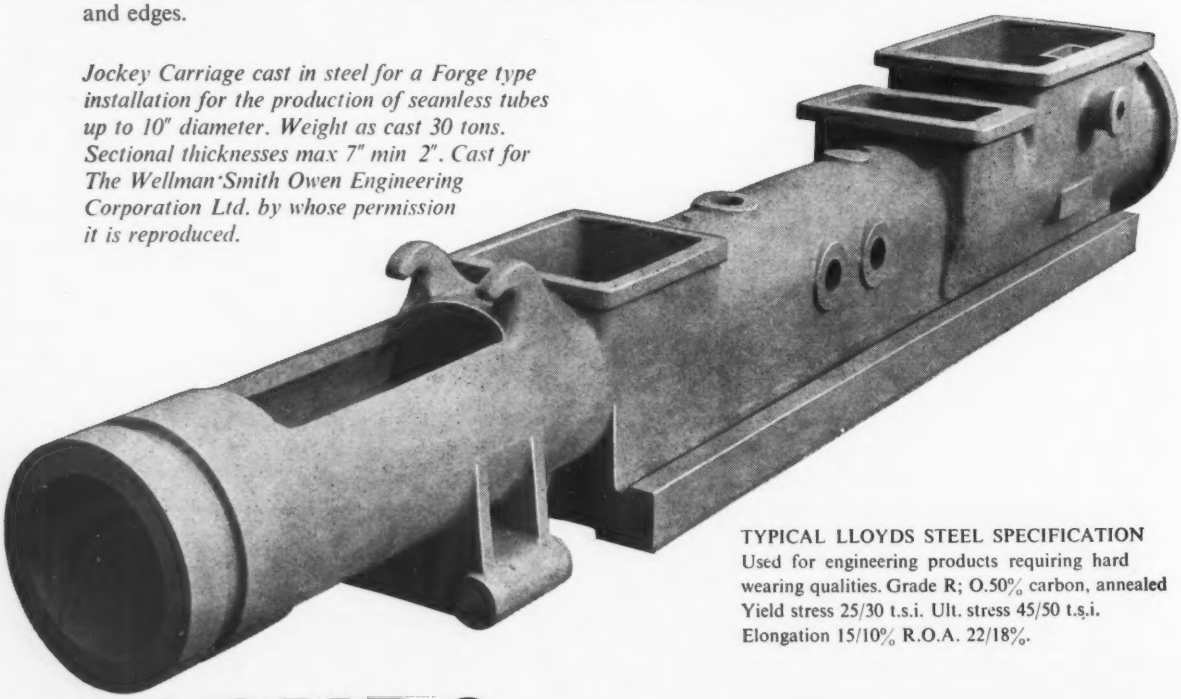
*APSB*



# cast for a "shockable" part

This jockey carriage is cast in steel for a forge type of installation for the production of seamless tubes up to 10″ diameter, and has to withstand unpredictable shock load. It is a good example of the versatility of steel casting, in that its sectional thickness varies from 2″ to 7″, essential requirements that make it almost impossible to fabricate by any other method.
Owing to good method planning this casting is free from defects and of especial interest is the fine finish. Note also the sectional thickness round the corners and edges.

*Jockey Carriage cast in steel for a Forge type installation for the production of seamless tubes up to 10″ diameter. Weight as cast 30 tons. Sectional thicknesses max 7″ min 2″. Cast for The Wellman·Smith Owen Engineering Corporation Ltd. by whose permission it is reproduced.*



TYPICAL LLOYDS STEEL SPECIFICATION
Used for engineering products requiring hard wearing qualities. Grade R; O.50% carbon, annealed
Yield stress 25/30 t.s.i. Ult. stress 45/50 t.s.i.
Elongation 15/10% R.O.A. 22/18%.

**LLOYDS** ***Britain's best equipped steel Foundry***

F. H. LLOYD & CO. LTD., P.O. BOX No. 5, JAMES BRIDGE STEEL WORKS, WEDNESBURY, STAFFS. TELEPHONE JAMES BRIDGE 2401

Print for Industry Advertisement

*accuracy* *productivity* *versatility*

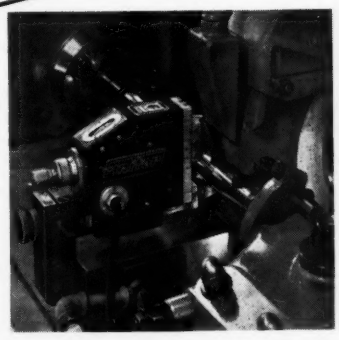
***are all features of the range of Precision Grinding Machines built by———————***

**FORTUNA-WERKE**
**SPEZIALMASCHINENFABRIK A.G.**
**STUTTGART**
**GERMANY**

**For Toolroom and Production**

*Illustration shows Model AFB, one of the wide range of types available in 2 sizes, 5.5/16 height of centres, 12" and 20" maximum distance between centres. Can be arranged as plain, universal or automatic machine and with infinitely variable wheel speed.*

*Automatic Sizing*



With FINITOR Automatic size control the measuring head which controls the cycle of the machine is in constant direct contact with the work during grinding.

Accuracy is thus independent of all variables inherent in the grinding operation.

***LET US DEMONSTRATE TO YOU***

NRP 1555

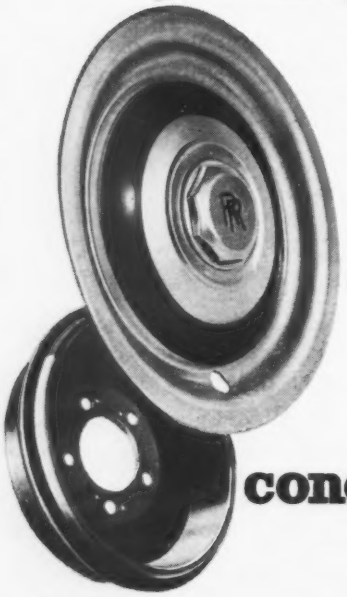
**VAUGHAN ASSOCIATES LIMITED**

**4 QUEEN STREET · CURZON STREET · LONDON · W.1** Tel: GROsvenor 8362

*Midland Office and Demonstration Room:* **WILFORD CRESCENT · NOTTINGHAM** Tel: NOTT 88008

for the little things that matter-

**consult concentric.**

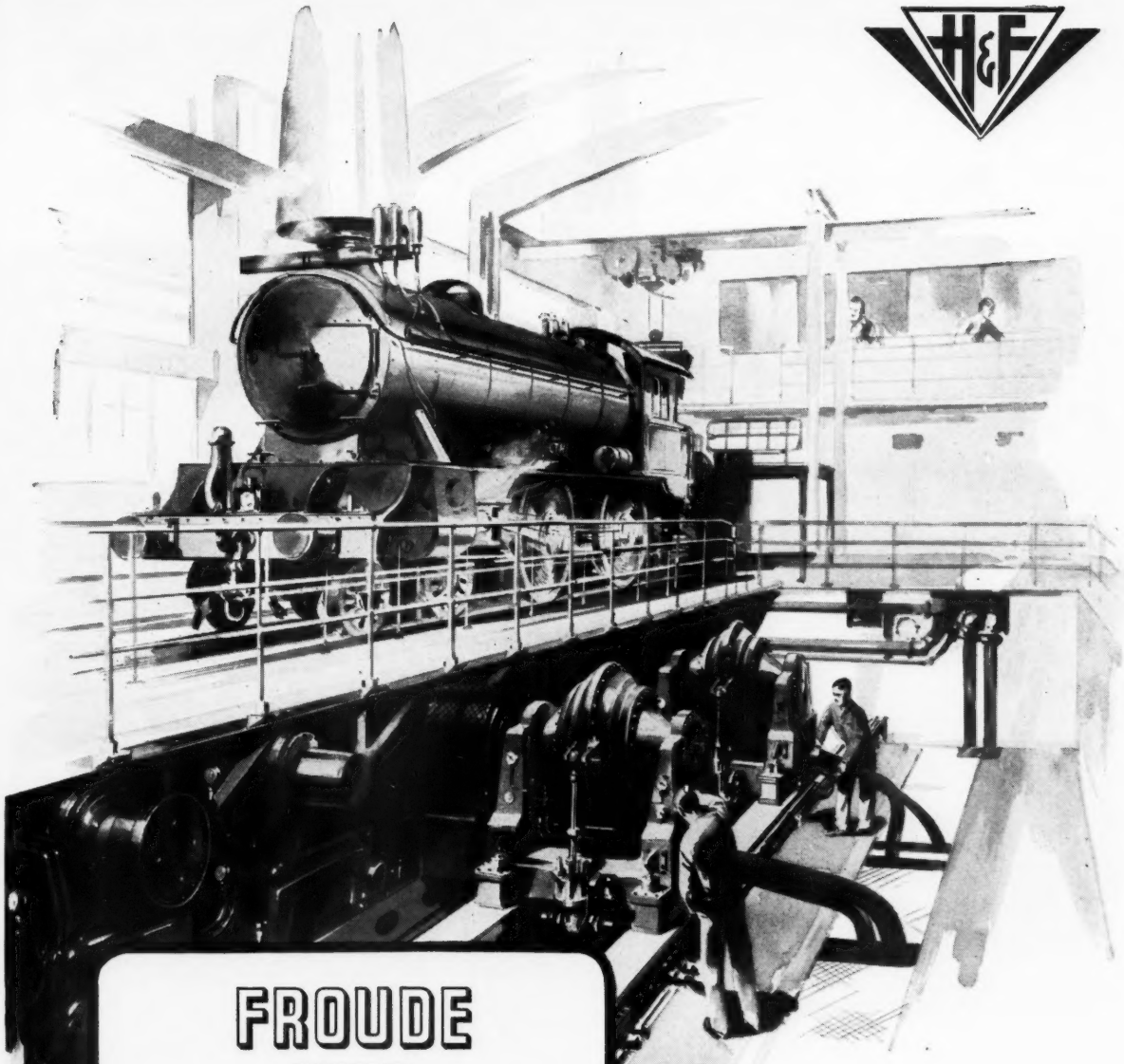


**WATER PUMPS, STEERING IDLERS, GEAR CHANGE MECHANISMS, BRAKE DRUMS, PUSH RODS, BALL PINS, SHACKLE PLATES, THRUST PLATE ASSEMBLIES, MACHINE COMPONENTS AND PRESSINGS OF ALL KINDS.**

Manufacturers of specialised precision engineered components with an established reputation for consistent quality, efficiency and long life — components that are fitted and forgotten, unsung and uncared for, yet — they rarely fail — they're made by Concentric.

**concentric manufacturing co. ltd.**

TYBURN ROAD. BIRMINGHAM. 24.



# FROUDE

PATENT

## HYDRAULIC DYNAMOMETERS

FOR ABSORBING AND MEASURING B.H.P. OF ALL TYPES OF PRIME MOVERS – SIZES RANGE FROM 50 TO 60,000 B.H.P. AND UPWARDS

The result of constant research and development combined with unrivalled experience

LOCOMOTIVE TEST PLANT
designed, manufactured
and installed complete
by HEENAN & FROUDE LIMITED
at BRITISH RAILWAYS'
RUGBY TESTING STATION.
Five Froude Dynamometers,
each of 1200 B.H.P.
capacity were incorporated.

Write for further particulars:

**HEENAN & FROUDE LIMITED** ENGINEERS, **WORCESTER, ENGLAND**

*Photograph by courtesy of Rolls-Royce Limited*

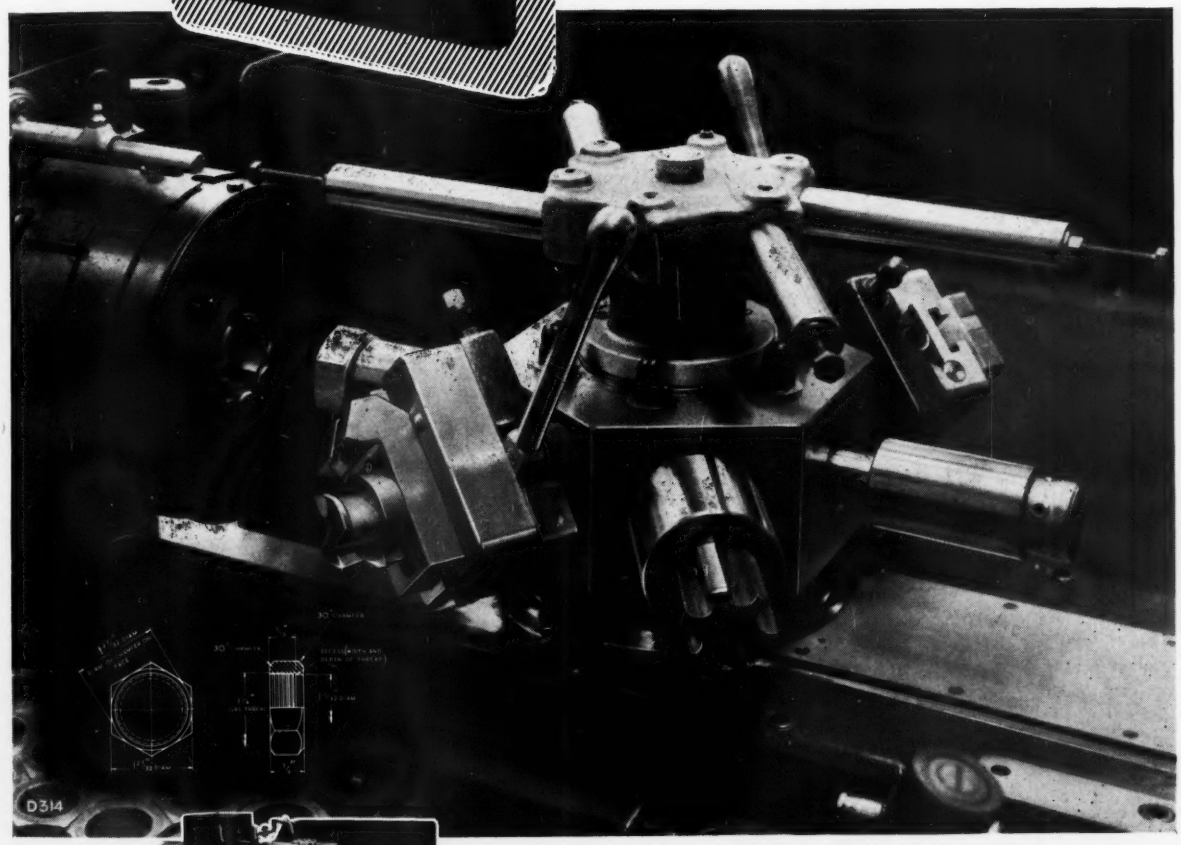
**More wear resisting than Tungsten Carbide**

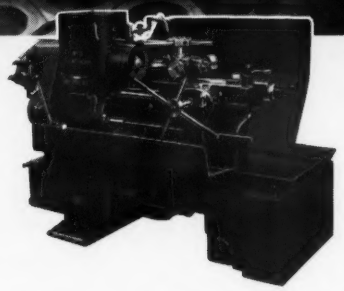
**C.T.B SHOT BLAST NOZZLES**

**Glostics Ltd**

AGENTS · **IMPREGNATED DIAMOND PRODUCTS LTD · TUFFLEY CRESCENT · GLOUCESTER**

Production on **HERBERT** *No. 2 Flashcap Lathes..*



The above illustration shows the machining of a zinc-base alloy gland nut on a Herbert No. 2 Flashcap Lathe.

The tooling is duplicated so that two nuts can be completed for each cycle of the turret.

**The floor-to-floor time, at a spindle speed of 1,270 r.p.m., is 8 seconds.**

*. . . . for high production of non-ferrous threaded components requiring frequent spindle reversals, up to thirty reversals per minute can be made*

**Most Herbert capstan and combination turret lathes are now available for early delivery**

ALFRED HERBERT LTD., COVENTRY

AD.380

## SAID Mr. DAWE

'Funny?' we said. 'Scientific instruments, funny?'

'Yes' said Mr. Dawe. 'That's what we need. You see, we here at Dawe Instruments know that our range of dynamic balancing apparatus is damned good. A lot of our customers know it, too, thank goodness. But the minute anyone starts writing an advertisement to say so, and heads it up with something like "Instruments of superb quality", somehow or other our stuff comes out at the end sounding no better than anyone else's. But a spot of humour now, that's different. Everyone likes that. And what's more, they remember it.'

'Something funny, then', we said uncertainly.

'Yes' said Mr. Dawe with commendable patience. 'Of course, you must emphasize the wide range of our apparatus. You know, it can cover assemblies weighing from as little as 1 oz. to as much as 150 lb.'

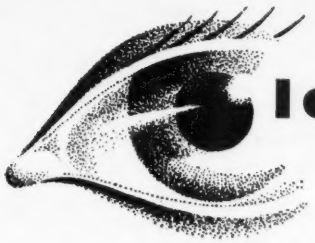
'We'll emphasize that', we said.

'Oh, by the way' Mr. Dawe added briskly, 'I almost forgot. We've got equipment to balance rotors in the form of cylinders or in the form of discs. And it doesn't matter whether components are mounted vertically or horizontally. Our equipment covers the lot. Just be funny about that too, will you?'

'We will', we said.

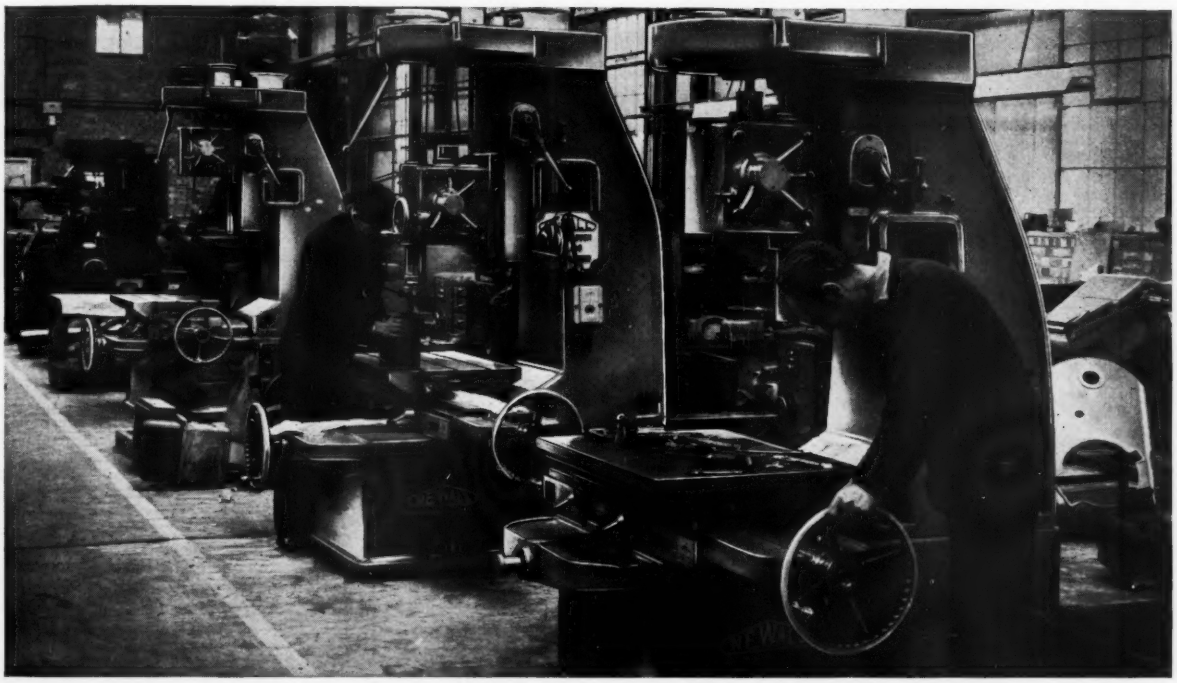
'And don't be too long about it', said Mr. Dawe.

**DAWE INSTRUMENTS LTD.**
**99-101 UXBRIDGE ROAD, EALING, LONDON, W.5 : EALING 6215**



# look for yourself

**Not only at a pictorial record of vital processes in our reprecisioning service, but at the complete rebuilding methods we employ . . . from stripping to final assembly and inspection tests against standards laid down by the actual machine manufacturers, The Institution of Production Engineers, or Dr. Schlesinger.**



***the hallmark of re-precisioning***

**Our new factory, fully equipped with modern, large capacity plant manned by specialists in rebuilding all types of precision and heavy machine tools, is always open to your inspection.**

NEWALL USED MACHINE DIVISION

**THE NEWALL ENGINEERING COMPANY LIMITED**
(USED MACHINE DIVISION)
OUNDLE ROAD · ORTON LONGUEVILLE · PETERBOROUGH
*Telephone: Peterborough 6116*

P1743

*Electrical Aids in Industry* *Data Sheet* **No.1**

# Electro-Heat

The ways in which electricity can be used to advantage in industry are many and varied. Some are well known but others are not known well enough. For this reason the Electrical Development Association has prepared a series of detailed data sheets on various applications which will be printed in this journal from time to time.

This Data Sheet is the first of a number devoted to electro-heat–that is, heat produced by electricity for the processing and treatment of materials. Other uses will be dealt with later on in the series.

There is an unalterable physical law that the efficiency of conversion of *electrical* energy to *heat* energy is 100 per cent. The same cannot be said of the efficiency of combustion of any solid or liquid fuel.

All the applications of electro-heat have these advantages in common :—

**1** Electro-heat is clean both in regard to its application and the method of generation.

**2** It can easily be controlled more precisely than any other form of heat, manually or automatically.

**3** It can be brought to the job instead of having the job brought to it.

**4** It permits better use of floor space and the elimination of unnecessary handling.

**5** In many of the newer processes it is the only possible form of heat which can be used.

**6** It often ensures a higher quality of products with fewer rejects.

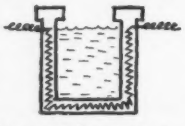
**7** It gives the best working conditions.

**8** It reduces or eliminates fire and explosion hazards.

Below will be found brief notes on some of the various methods of generating heat by electricity.

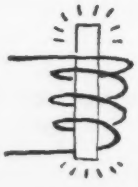
### *Resistance Heating*

This is the best known form of electric heating. The elements provide a high resistance to the passage of electricity and thus heat is generated. It can be used in furnaces for melting or heat treatment of any material whether metal or not, or the resistance of the workpiece itself can cause the generation of heat.



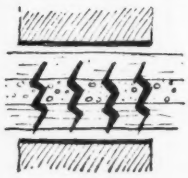
### *Induction Heating*

Eddy currents are induced in the surface of a conducting workpiece, heating it up. The depth to which this heating will penetrate is determined by the time it is given.



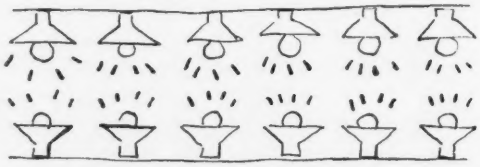
### *High-frequency Dielectric Heating*

This form of electro-heat can be used only on non-conducting materials such as wood, plastic and rubber. The material is placed between two electrodes to which a high voltage is applied at a high frequency. This has the effect of generating heat inside the material rapidly and uniformly throughout its entire thickness.



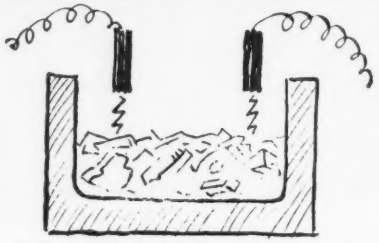
### *Infra-red Heating*

This method employs pure radiant heat. The bulk of the radiation takes place in the infra-red portion of the radiation frequency spectrum. The heaters may take the form of reflector lamps or sheathed wire elements. The method is extremely flexible and has many uses, including paint drying and pre-heating plastics.



### *Arc Melting*

This form of heating is chiefly used for melting steel. The diagram illustrates one method of operation.



Very large charges can be melted; melting units of 200 tons capacity are now in operation.

### *The Application of Electro-Heat*

All these methods of electric heating can be applied in almost an infinite variety of ways. Some of these ways will be dealt with in subsequent sheets.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2.

Excellent reference books on electricity and productivity (8/6 each or 9/- post free) are available—"Induction and Dielectric Heating" is an example; "Resistance Heating" is another.

E.D.A. also have available on free loan a series of films on the industrial use of electricity. Ask for a catalogue.

# Shadomaster REGD

## *Speed and accuracy in PRODUCTION requires even greater speed and accuracy on INSPECTION*

*Our resident Optacologist ( Watford ) demonstrating the Model A.450 Mk.II*

Picture shows part of the SHADOMASTER section of our new Showrooms at Watford where all instruments and accessories in the extensive SHADOMASTER range are available for demonstration.

**Shadomaster** REGD

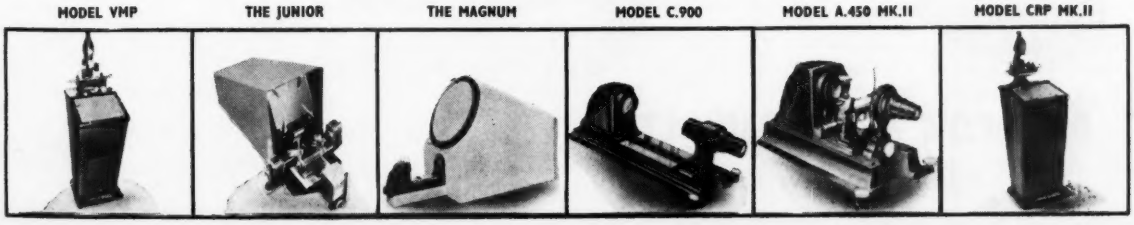
**PRECISION TRUE-GAUGE AND PROFILE PROJECTORS FOR ECONOMIC INSPECTION**

**BUCK & HICKMAN LTD**

**OTTERSPOOL WAY · WATFORD-BY-PASS · HERTS.**
*TELEPHONE: WATFORD 6681*

Head Office: **P.O. Box No. 74, Whitechapel Road, London, E.1**
Branches: **Alperton, Birmingham, Bristol, Glasgow, Leeds, Manchester**

***For full information write for SHADOMASTER brochure***

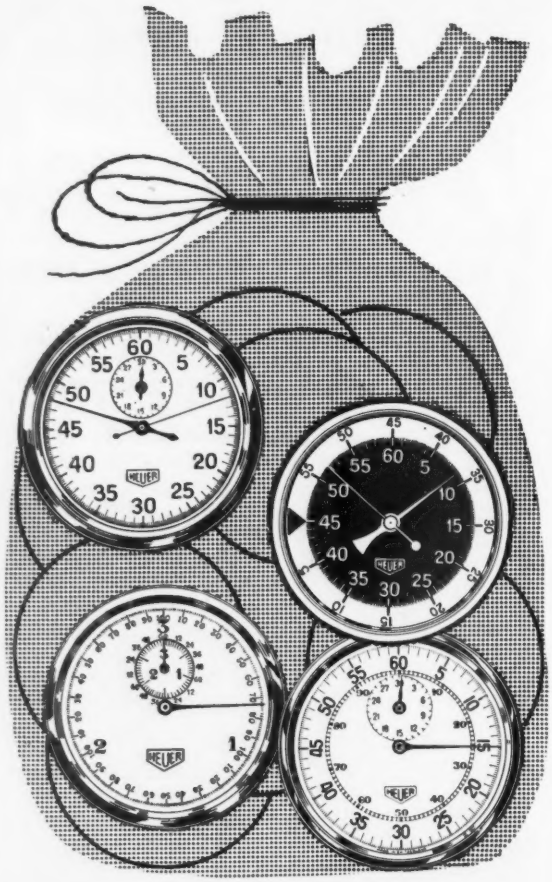


P.B.COW
for rubber

**P. B. COW & COMPANY LTD**

INDUSTRIAL DIVISION

470 HIGH ROAD STREATHAM COMMON S.W.16



# Where time is money

**Watches of Switzerland Ltd.**

**present**

**HEUER TIMERS**

Is time money to you? Then ask Watches of Switzerland Ltd. about Heuer timers. There is a model to meet every industrial need; for instance the Heuer Ringmaster $\frac{1}{5}$ second timer has 7 interchangeable and individually calibrated dials. However complicated your Heuer timer, its parts are standardised for quick repairs and replacements. Write for catalogue to:

**Watches of Switzerland Ltd.**

**Head Office & Technical Dept., 34-36 Beech Street, E.C.1**

**PROPERTIES of DMC MOULDINGS**

EXCELLENT MECHANICAL STRENGTH
HIGH IMPACT STRENGTH
DIMENSIONAL STABILITY
TEMPERATURE RESISTANCE
GOOD DIELECTRIC STRENGTH
RESISTANCE TO TRACKING
LOW WATER ABSORPTION
CORROSION RESISTANCE

# DMC* mouldings

(POLYESTER/GLASS FIBRE)

## for high mechanical and electrical strength at economical cost

All the mechanical/electrical advantages of polyester/glass fibre are yours to exploit—with the added virtue of economy. *Dough Moulding Compound is the new material that speeds and simplifies moulding because it needs only low pressures and short cure times in conventional compression presses. The proportions of resin, fibre and filler can be varied to emphasise desired properties, according to applicational need, or for cost advantages. STREETLY technicians have thoroughly investigated the characteristics and mould behaviour of all the reasonable permutations of this versatile material; production runs have provided first-hand practical experience. We are therefore in an unrivalled position to supply large numbers of DMC mouldings, produced in automatically controlled BIPEL presses with the exactitude for which STREETLY is so well-known.

*Kelvinator refrigerator door latch moulding. DMC material imparts high mechanical strength throughout and excellent resistance to extremes of temperature. Moulded by the Streetly Manufacturing Co. Ltd., for Kelvinator Limited, Crewe.*

**ESTABLISHED APPLICATIONS**

**Transport**

*Car and bus heater housings, air ducts, fan blades, seat bases and sides, armrest foundations, door panels, window strips*

**Electrical**

*Stand-off insulators, coil forms, brush holder insulators, support blocks, switch boxes and covers, circuit breaker bases, battery housings*

**Domestic**

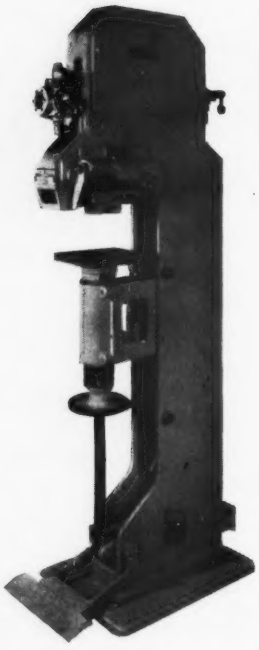
*Washing machine impellers, spin dryers, refrigerator parts, suction cleaner parts, furniture handles, door handles, sports goods*

**DMC** for strength — **STREETLY** for **DMC** mouldings

THE STREETLY MANUFACTURING CO. LTD · STREETLY WORKS · SUTTON COLDFIELD · TELEPHONE: STREETLY 2411

*may we present*

## OUR LATEST E.P. 34A AIR-OPERATED MARKING MACHINE



This machine, the latest addition to the PRYOR range of marking equipment, simplifies and speeds up the marking of an extremely wide range of cylindrical and flat components. Air operation ensures exact uniformity of impression and reduces operator fatigue to a minimum. A full range of type holders, and geared roller-die carriers is available. Full details of this machine and of our hand-operated models will be sent on request.

FOR FASTER, SIMPLER, GENERAL PURPOSE MARKING AND GENUINE CUTS IN MARKING COSTS, WRITE FOR FURTHER DETAILS TO :-

**EDWARD PRYOR & SON LIMITED**

**BROOM STREET • SHEFFIELD • ENGLAND**

**PHONE: SHEFFIELD 23161 (5 lines) • GRAMS: PRYOR, SHEFFIELD**

---

## *NEW BESCO All Steel PRODUCTION MOTORISED GUILLOTINES*

In answer to demand for compact, lightweight, inexpensive sheet metal guillotines, F. J. EDWARDS have produced these motorised guillotines.

The frames cannot be broken by even extra-ordinary factory use, being of welded steel plate construction.

Planned to a price and designed for a job, they will cut their capacity day after day.

A new-design clutch, which is simplicity itself; all round and accurate gauges and an automatic built-in hold-down make the operator's job easier, quicker and safer.

In addition to cutting all kinds of sheet metal, these machines are also suitable for cutting fibre, plastics, mica, rubber, paper, card, with the blade ground to a special angle.

And they are from London stock too.

Fuller details will be sent on request together with prices and, if required, information concerning deferred payments in United Kingdom.

| *Model* | *Ungeared* | *Geared* | *Geared* |
|---|---|---|---|
| Capacity | 36½" x 18 s.w.g. Mild Steel | 36½" x 16 s.w.g. Mild Steel | 49" x 16 s.w.g. Mild Steel |

**Designed and built by . . .**

**F.J. Edwards Ltd**

**EDWARDS HOUSE, 359-361 EUSTON ROAD, LONDON, N.W.1**
Telephones: EUSton 4681 (7 lines) 3771 (4 lines) Telegrams: Bescotools Norwest London

**LANSDOWNE HOUSE, 41 WATER STREET, BIRMINGHAM, 3**
Telephones: CENtral 7606-8 Telegrams: Bescotools Birmingham 3

# the Rocol technical information service

## Brochures dealing with

# SPECIALISED LUBRICANTS

## for industry

rdh 10683/A

*Engineering and other industrial firms are offered the following, as one aspect of* ROCOL *service.*

*Publication No.* 1. **ANTI-SCUFFING PASTE AND OIL**
Anti-Scuffing Paste is the most effective means of applying Molybdenum Disulphide for dry lubrication. Used where ordinary oils and greases cannot be applied. Withstands immense heat and pressure, and has remarkable anti-seize properties. Approved under D.T.D. 900/4284. Anti-Scuffing Oil enables Molybdenum Disulphide to be used in circulating systems and oil lubricators.

*Publication No.* 2. **R.T.D. COMPOUND**
The modern lubricant for severe metal forming and shaping operations. Counters the effects of high pressure and eliminates frictional heat in drilling, reaming and tapping stainless steel, alloy steels, nickel and titanium. Can lengthen tool life by as much as 30 times.

*Publication No.* 3. **MOLYBDENISED LUBRICANTS**
The remarkable low friction and pressure resisting properties of Molybdenum Disulphide have been incorporated in a wide range of specialised lubricants, compounds and varnishes described in this Brochure.

*Publication No.* 4. **WATCH AND CLOCK OILS**
A complete range for the Horological and Instrument Engineer, based on joint research of horologists and oil technicians. Includes a range of synthetic oils which remains fluid down to minus 65 C; and Molybdenised Oils in all viscosities.

*Publication No.* 5. **KILOPOISE LUBRICANTS**
Extreme-viscosity lubricants to damp motion and ensure a slow, even action in hand operated components such as optical focusing movements, variable condensers and potentiometer spindles. Widely used throughout the optical, instrument, radio and electronic industries. Special grades available for use as Core Locking Compounds.

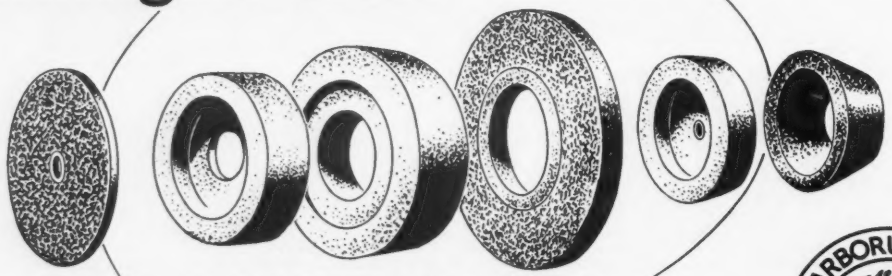
*Publication No.* 8. **MOLYTONE GREASE**
A series of greases combining Rocol Bentone Grease and Molybdenum Disulphide. They have no melting point and are effective from below zero to 450 F. They withstand extreme pressures and provide positive lubrication even in 'starved' conditions. They should be used in all grease systems where extra boundary lubrication is demanded by severe working conditions.

*Write to* ROCOL *about lubrication.*

**ROCOL LIMITED**

Ibex House, Minories, London, E.C.3. (*Telephone:* ROYal 4372)
Rocol House, Swillington, nr. Leeds. (*Telephone:* Garforth 2261/2)

# Grinding Wheels



by **CARBORUNDUM**
TRADE MARK

THE CARBORUNDUM Co. Ltd. MANCHESTER

**AND COATED ABRASIVES—**
**Coated cloths and paper, sheets, rolls, discs, belts, etc. for the Engineering and Metal Polishing Trades**

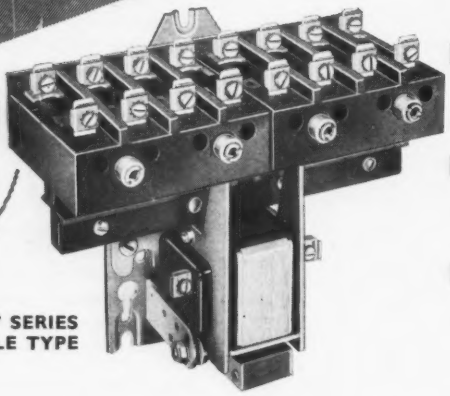
*Midland Stockists and Service Agents for Abrasive Products by* CARBORUNDUM

*Richard Lloyd Limited*
GALTON HOUSE, ELMFIELD AVENUE, TYBURN, BIRMINGHAM, 24
*Telephone: ASHfield 1801 Telegrams: "Cogs, Birmingham" Telex No. 33366*

---

## *The IDEAL range of RELAYS...*

*for*
**AUTOMATION LINE CONTROL**



**"FMP" SERIES 8 POLE TYPE**

- ***ANY* combination of normally open or normally closed poles up to *EIGHT***
- ***Contact rating 15 AMPS at 600 VOLTS A.C.***
- ***Available as 'plug-in' types***
- ***Latching attachment optional***

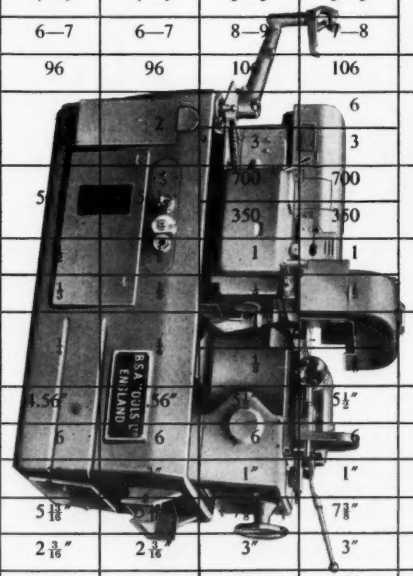
*Write TODAY for our NEW Motor Control Gear Catalogue MS10*

**ARROW ELECTRIC SWITCHES LTD.** HANGER LANE · LONDON · W.5

ARROW

A19

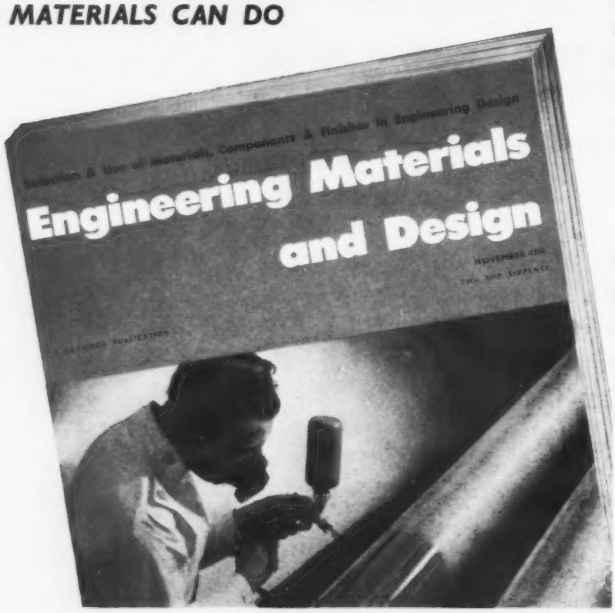
| MACHINE | | 48 | 68 | 18L | 25L | 68L | 88L | 98L | 138L | 168L | METRIC 24 | METRIC 36 | METRIC 52 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Workspindle capacity | round | ½″ | ¾″ | 18 mm. | 25 mm. | ¾″ | 1″ | 1¼″ | 1⅝″ | 2″ | 24 mm. | 36 mm. | 52 mm. |
| | square | .353″ | ½″ | 13 mm. | 18 mm. | .0530″ | .0708″ | 11/16″ | 1⅛″ | 1.414″ | 17 mm. | 25.4 mm. | 35 mm. |
| | hexagon | .437″ | ⅝″ | 16 mm. | 22 mm. | 0.650″ | 0.866″ | 13/16″ | 1⅜″ | 1.730″ | 20 mm. | 30 mm. | 45 mm. |
| Max feed in one movement | long stroke | 2″ | 3″ | 75 mm. | 75 mm. | 3″ | 3″ | 4″ | 4″ | 4″ | 90 mm. | 90 mm. | 90 mm. |
| | short stroke | 1″ | 2″ | | | 2″ | | 2½″ | 2½″ | | | | |
| Stroke of turret cam (standard) | | 1⅜″ | 2¼″ | 50 mm. | 50 mm. | 2¼″ | 2¼ | 3″ | 3″ | 3″ | 80 mm. | 80 mm. | 80 mm. |
| Max. diameter using diehead | | ⅜″ fine | ⅝″ fine | 16 mm. | 16 mm. | ⅝″ fine | ⅝″ fine | 1″ | 1¼″ | 1¼″ | 18 mm. | 18 mm. | 18 mm. |
| Range of spindle speeds | | 166—7,370 | 53—4,480 | 40—4,500 | 40—4,500 | 53—4,480 | 53—4,480 | 70—3490<br>24—3590 | 78—2300<br>25—2540 | 69—1,520 | 38—3,000 | 24—1,900 | 30—1,500 |
| Number of high speeds | 4 speed | 18 | 10 | 14 | 14 | 10 | 10 | 22 | 19 | 17 | 10 | 10 | 8 |
| | 2 speed | | | 14 | 14 | 10 | 10 | 13 | 12 | | | | |
| Low speeds available for each high speed | | 2 | 10 | 11—13<br>9—10 | 11—13<br>9—10 | 7—9<br>6—7 | 7—9<br>6—7 | 3—5<br>8—9 | 3—5<br>7—8 | 3—5 | 4—5 | 4—5 | 4—5 |
| Number of cycle times | | 46 | 65 | 96 | 96 | 96 | 96 | 10 | 106 | 106 | 46 | 46 | 46 |
| Cycle time range (secs) fastest | long stroke | ¾ | 2 | 2 | 2 | | | | 6 | 6 | 8 | 8 | 8 |
| | short stroke | ¾ | | | | | | | 3 | | | | |
| slowest | long stroke | 75 | 180 | 561 | 561 | 5 | | 700 | 700 | 700 | 360 | 360 | 360 |
| | short stroke | 56½ | | | | | | 350 | 350 | | | | |
| Actual time to feed stock (secs) | long stroke | ⅓ | ½ | ½ | ½ | | | 1 | 1 | 1 | 1 | 1 | 1 |
| | short stroke | ⅓ | ⅓ | | | | | | | | | | |
| Time to change speed (secs) | long stroke | ⅙ | ¼ | ¼ | ¼ | | | ⅛ | | ¼ | ¼ | ¼ | ¼ |
| | short stroke | ⅙ | ⅙ | | | | | | | | | | |
| Diameter of turret | | 3⅜″ | 4 1/16″ | 116 mm. | 116 mm. | 4.56″ | 4.56″ | 5″ | 5¼″ | 5½″ | 140 mm. | 140 mm. | 140 mm. |
| Number of turret holes | | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Diameter of turret holes | | ⅝″ | ¾″ | 19.05 mm. | 19.05 mm. | | | 1″ | 1″ | 1″ | 25.4 mm. | 25.4 mm. | 25.4 mm. |
| Distance chuck to turre | max. | 3⅜″ | 5⅜″ | 120 mm. | 120 mm. | 5 11/16″ | | | 7⅜″ | 7⅜″ | 180 mm. | 180 mm. | 180 mm. |
| | min. | 1 13/16″ | 2⅜″ | 49 mm. | 49 mm. | 2 3/16″ | 2 3/16″ | 3″ | 3″ | 3″ | 64 mm. | 64 mm. | 64 mm. |
| Turret slide adjustment | | 5/16″ | ¾″ | 21 mm. | 21 mm. | 1 5/16″ | 1 5/16″ | 1¼″ | 1¼″ | 1¼″ | 38.1 mm. | 38.1 mm. | 38.1 mm. |
| Spindle centre to top of cr | slide | 1″ | 1 5/16″ | 30 mm. | 30 mm. | 1 5/16″ | 1 5/16″ | 1 7/16″ | 1 7/16″ | 1 7/16″ | 36 mm. | 36 mm. | 36 mm. |
| Movement of cross slide | | 1″ | 1¼″ | 32 mm. | 32 mm. | 1¼″ | 1¼″ | 1¾″ | 1¾″ | 1¾″ | 40 mm. | 40 mm. | 40 mm. |




B.S.A. TOOLS LTD · BIRMINGHAM 33 · ENGLAND

AGENTS U.K. BURTON GRIFFITHS & CO LTD · KITTS GREEN · BIRMINGHAM · STECHFORD 3071

## *KNOW WHAT THE NEW ENGINEERING MATERIALS CAN DO*




"What is wanted is an easily read but authoritative publication which will keep busy engineers and scientists bang up to date with the latest developments in materials and engineering design without taking too much time. After looking through the proofs of the first number of **Engineering Materials & Design** I believe it can do just that."

**Sir Donald Bailey, O.B.E., D.Eng., A.M.I.C.E., Vice-President, Institute of Engineering Designers.**

**The second issue of Engineering Materials & Design is now on sale. All concerned with cutting costs and improving product performance must see this unique journal every month.**

**Contents of November issue :**

Fatigue of Welded Structures
New Developments in P.T.F.E. Materials
Design Factors in Silver Brazing
Selection of F.H.P. Motors — Part II
Epoxy Resin Mouldings
Aluminium Strip and Foil for Windings
Stainless Steel for High Strength

Order YOUR copy of **Engineering Materials & Design** TO-DAY

**From all bookstalls and newsagents 2s. 6d.**
**By subscription, 35s. sterling ($5.25 U.S.A. & Canada) for 12 issues including postage from The Circulation Manager, Heywood & Company, Ltd., Drury House, Russell Street, London, W.C.2.**

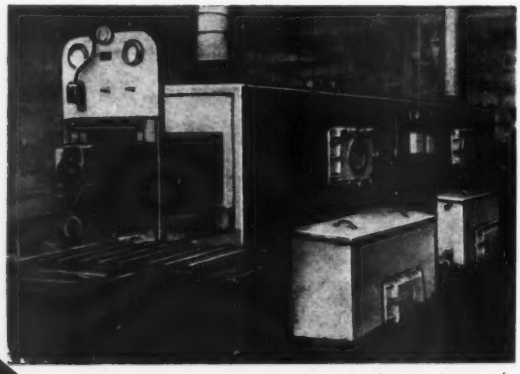
# Bratby

## INDUSTRIAL CLEANING MACHINES

*can be designed to meet your particular cleaning problems*

Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible, to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. We can help with **your** cleaning problem — why not consult us ?

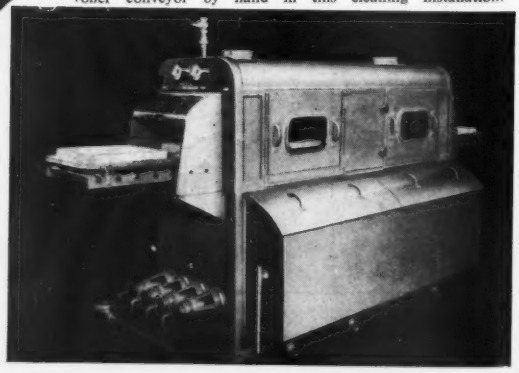
**BRATBY & HINCHLIFFE LTD**
**GORTON LANE · MANCHESTER 18 · Tel: EAST 2435**



**HERE ARE TWO EXAMPLES**

This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.

Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.



# New, Compact

## Speedomax Type H with additional controls integrally mounted

Here is a completely new model of the Speedomax Type H potentiometer with additional controls now an integral part of the main instrument.

It is very compact, saving much panel space, being $17\frac{5}{8}$″ high × 11″ wide × 11″ deep

Speedomax Type H is a real null-balance potentiometer with plug-in components, simple range changing and external terminal boards.

It is a first-class engineering job, the L & N practice of operating all moving parts by means of a common shaft which is driven by the positive worm gear of a high speed balancing motor being maintained.

It will be seen that additional controls are now an integral part of the main instrument and pull out like a drawer

**It is lower in cost than any comparable electronic potentiometer available today.**

It is made complete in our Birmingham Works and delivery is good—at present about 8 weeks. We will give you a demonstration at your works with pleasure.

*Send today for the new Speedomax H Catalogue*

**INTEGRA, LEEDS & NORTHRUP LTD.**

183, BROAD STREET, BIRMINGHAM, 15

Telephone: MIDLAND 1453/4 Telegrams: FLOMETER, BIRMINGHAM

British made in Birmingham

*How many per minute?*

**Noral**

# 28S

## free cutting aluminium alloy

Noral 28S free-cutting alloy machines even better and faster than conventional aluminium alloys! No build-up on the cutting tool, no awkward long pieces of swarf! It costs, volume for volume, little more than half as much as free-cutting brass.
How fast can you produce parts such as this television coaxial plug component? With Noral 28S it depends only on the capacity of the machine!
May we send you further details?

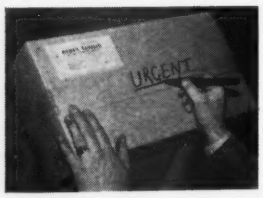
NORTHERN ALUMINIUM COMPANY LTD · BUSH HOUSE · ALDWYCH WC2 · TEMPLE BAR 8430 · AN ALUMINIUM LIMITED COMPANY

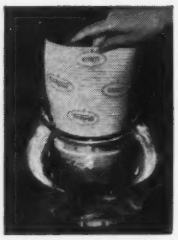
raw/116

OFREX · Fordigraph · INDUSTRIA · SPEEDFIX SELF-ADHESIVE Tape

## SPEED THE MAILS

Make a press button job of time wasting office folding — whether correspondence, invoices or circulars. Fordigraph FASTFOLD : compact in size : simple in use : inexpensive to install. Full details Ref. J.I.P.E. 149.



## SAVES MARKING TIME

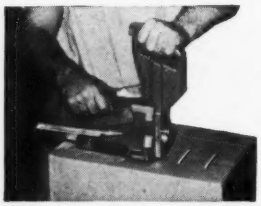
New Ofrex precision made instrument for marking, writing, painting, stencilling. As you write, so it dries with startling suddenness. Marks paper, china, metal, cloth, glass, plastic, etc Full details Ref. J.I.P.E. 221.

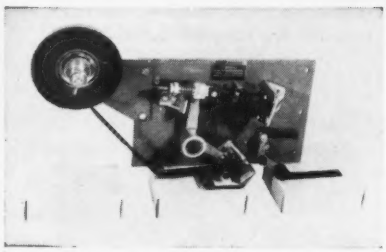
## CLEAN UP SPIRIT PROCESS WORK

No special fittings or adaptations or fluids needed with AZURITE, new Fordigraph chemical sheet for spirit process master making. Insoluble in water and **therefore** clean to handle and clean to use. Ref. J.I.P.E. 152.

## KING SIZED Staples = KING SIZED Savings

New Industria carton sealer eliminates wire strapping, glueing and taping — seals cartons securely in split seconds at a fraction of conventional costs. Full details Ref. J.I.P.E. 528.





## TAPED AT 75 per minute

New I.T. automatic flat surface applicator unites well-tried economy of self-adhesive taping with flowline application method. Full technical details Ref. J.I.P.E.339.

**To: OFREX GROUP CENTRAL INFORMATION SERVICE**
*Ofrex House, Stephen Street, London, W.1. MUSeum 3686*

*Please let me have more information about products ticked as under :-*

**OFREX MARKER 221**

**FASTFOLD 149** **AZURITE 152**
**CARTON SEALER 528** **AUTOMATIC TAPER 339**

*Executive's Name* .....

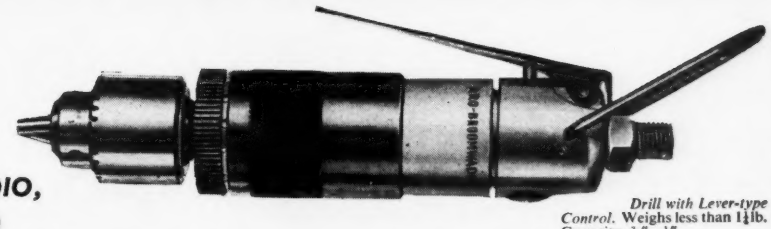
*(Staple this to your letter-head)*

(J.I.P.E) O.G.12

# NEW "ARO-BROOMWADE" Pneumatic Tools

## FOR MAXIMUM PRODUCTION

**IDEAL FOR AIRCRAFT, TELEVISION, RADIO, ELECTRICAL AND OTHER LIGHT INDUSTRIES**



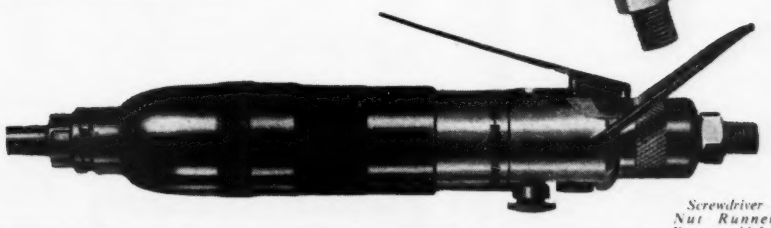
*Drill with Lever-type Control.* Weighs less than 1¼lb. Capacity $\frac{3}{16}$" - $\frac{1}{4}$".

*Drill with Pistol Grip Control.* Weighs less than 1¼lb. Capacity $\frac{3}{16}$"-$\frac{1}{4}$".

★ LIGHT
★ POWERFUL
★ SPEEDY
★ RELIABLE
★ LOW COST

Built by "BROOMWADE" to the designs of the ARO Corporation, Bryan, Ohio, leaders in the U.S.A. in the development of light pneumatic tools for industry.

***Write for full details NOW.***



*Screwdriver & Nut Runner.* Reversible. Weighs only 1¼lb. Adjustable clutch can be pre-set for correct torque. Silent in operation.

**"BROOMWADE"**

**AIR COMPRESSORS & PNEUMATIC TOOLS**

**YOUR BEST INVESTMENT**

**BROOM & WADE LTD., P.O. BOX No. 7, HIGH WYCOMBE, ENGLAND**

*Telephone: High Wycombe 1630 (10 lines). Telegrams: "Broom", High Wycombe, Telex. 543 SAS*

# Is yours a wire problem?

The perfect solution to a difficult problem of material selection has often been found in aluminium alloy wire.

AWCO supply a wide range of materials suitable for forming, machining, stamping or coining, all processed under closely controlled conditions in a modern plant.

We welcome your enquiries.

AWCO

**ALUMINIUM WIRE & CABLE CO. LTD**

Britain's Largest Manufacturers of Aluminium Wire & Conductors
Head Office and Works : PORT TENNANT, SWANSEA, GLAMORGAN
Sales Office : 2 ST. JAMES'S SQUARE, LONDON, S.W.1.
Telephone : TRAfalgar 6441
*and at* 13 Colmore Row, Birmingham, 3. Telephone : Central 2407

*AP 54*

# 8 machines in one!

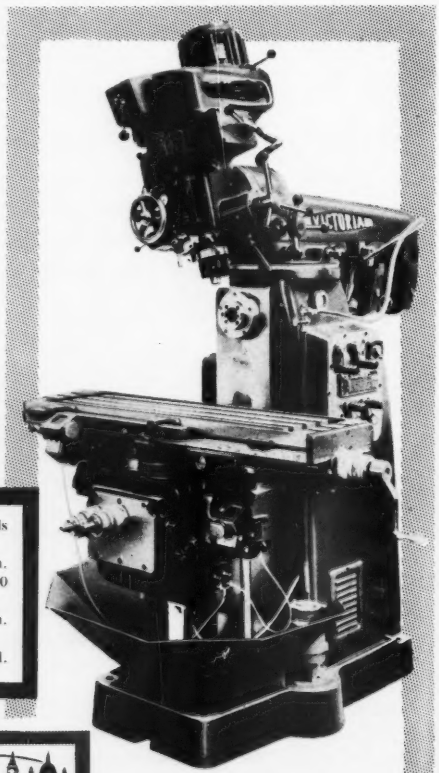
Jig boring
Diesinking
Drilling
Horizontal milling
*Vertical milling
*Universal milling
*Slotting
*Shaping

With the Victoria 01 or 02 Omnimil and standard attachments* as used with your Victoria U1 and U2 universal millers.

01—40" × 11" table, power longitudinal table feed 3 hp spindle motor.

02—45" × 11" table, power feed to all table movements, 4 hp spindle motor.

**OPTICAL MEASURING EQUIPMENT** (as illustrated) or dial gauges and measuring rod troughs available as extra equipment.



VICTORIA OMNIMIL

- ★ 12 horizontal spindle speeds 31 - 1010 r.p.m.
- ★ 18 table feeds 0.4 - 12.25 in./min.
- ★ 8 vertical spindle speeds 80 - 2700 r.p.m.
- ★ 3 power feeds .0015 in., .003 in. and .006 in. with auto trip.
- ★ Coarse and micrometer hand feed.

NRP1462

Manufactured by
**B. ELLIOTT (MACHINERY) LTD.**
(MEMBER OF THE B ELLIOTT GROUP)
VICTORIA WORKS, WILLESDEN, LONDON, N.W.10
Telephone: ELGar 4050 (10 lines) Telegrams: Elliottma, Harles, London
Overseas Subsidiaries: CANADA, U.S.A., AUSTRALIA, S. AFRICA

ELLIOTT OF LONDON GROUP

# Get down to the brass tacks of COMPUTERS

Ordering a computer is relatively easy. Choosing the right one, understanding its use, harnessing it to specific problems, is quite another matter. It is a long process. It needs much probing into the fundamental organisation of your business. Only people who are both computer men and business experts can help you. These are at your service at the Hollerith Computer Centre.

**At 36 Hertford Street** the Hollerith Computer Centre provides a convenient forum, round a working computer, for the exchange of ideas and results. There are several ways of making use of the Centre. Here are two examples:

**Higher Management Courses** — which provide a concise appreciation of computers in business, with maximum emphasis on case studies of computer usage. These courses last 4 days.

**Study Teams** from individual organisations come to discuss their own specific problems with our computer experts — production control, for example. These courses last from 1 to 5 days.

If you want to see how a computer could solve your particular problem, come and make use of us, come and pick our brains.

at the

HOLLERITH

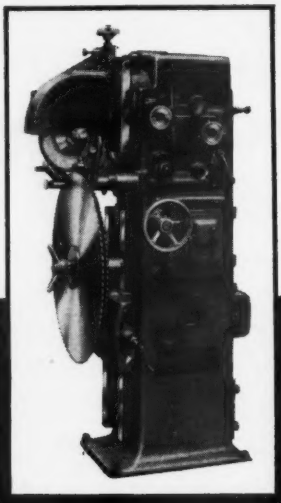
COMPUTER CENTRE

36 HERTFORD STREET, LONDON, W.1 GRO 1765

* *Enquiries about the Hollerith Computer Centre can be addressed to any of the district or local offices of* The British Tabulating Machine Company Limited, *or to Head Office:* 17 Park Lane, W.1 *

RUSSELL

# METAL SAWING MACHINERY



**The Russell Hydrofeed range includes :**

• Straight and angular cutting models • Automatics • Verticals • Special Billet cutting models

**Patented Features :**

• Interlocking Vices — for easier setting • Hydraulic Circuit — for efficient cutting

**SAW SHARPENING MACHINE**
*Capacity 11" to 48" blades*
**'HYDROFEED' COLD SAWING MACHINE**
*Automatic bar feed*

**S. RUSSELL & SONS LIMITED**
**LEICESTER, ENGLAND**

**Backed by over 40 years' specialised experience**

SR582

VACU-BLAST *is the primary requirement for anti-corrosive treatment*

Wherever there is a corrosion problem surface preparation is essential and Vacu-Blast is the natural answer. Whether it be metal spray, rubber covering, plastic coating or painting the simple rule applies — "clean surface thoroughly before application"; yet thousands of tons of expensive materials are wasted annually by failure to comply. Vacu-Blast offers the means to secure this basic requirement because it incorporates a dust-free closed circuit system of grit blasting especially suitable for in-situ work on plant installations. Demonstrations can be arranged on request.

PAE/A

**VACU-BLAST LTD., BATH ROAD, SLOUGH, BUCKS.** *Phone : SLOUGH 24507/9*
**VACU-BLAST AUSTRALIA (PTY.) LTD., ELIZABETH STREET, MITCHAM, VICTORIA, AUSTRALIA**

**A Multi Station Indexing Machine producing Differential Pinions of the Massey-Ferguson 35 Tractor at a production time of one set of four per 100 seconds.**

*Photo by courtesy of The Standard Motor Co. Ltd.*


# The latest techniques in mass production...

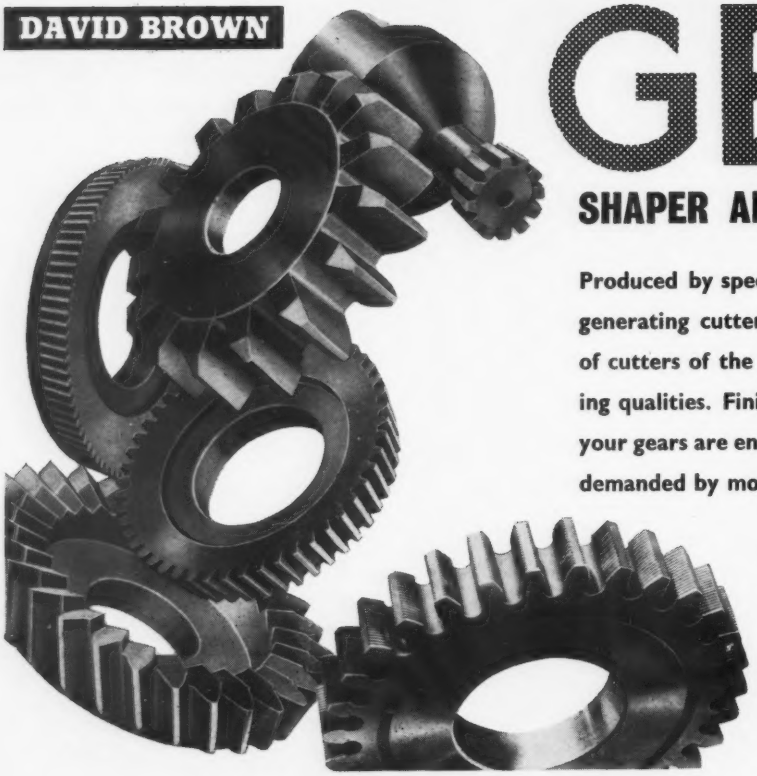
# FIRTH BROWN

## ...demand the latest techniques in steel making

ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

THOS FIRTH & JOHN BROWN LIMITED · SHEFFIELD · ENGLAND

**DAVID BROWN**



# GEAR

## SHAPER AND SHAVING CUTTERS

**Produced by specialists in the manufacture of gear generating cutters, we are proud to offer a range of cutters of the utmost precision and wear resisting qualities. Finished by DAVID BROWN cutters, your gears are ensured of the accuracy and precision demanded by modern high speed transmissions.**

*WRITE FOR FULL PARTICULARS TO-DAY!*

THE
**DAVID BROWN**
CORPORATION (SALES) LIMITED
TOOL DIVISION
PARK WORKS HUDDERSFIELD

---

# when heat is the problem

*RIGHT* Air-cooled Torch. For currents up to 100 amps.

*LEFT* Water-cooled Torch. Maximum current capacity 350 amps.

**British Oxygen fit their Argonarc welding torches with SINTOX Ceramic Shields, having proved that SINTOX successfully withstands the thermal stresses imposed by the process. SINTOX *is in the forefront of industrial development.***

# ...the unfailing answer is

STAS

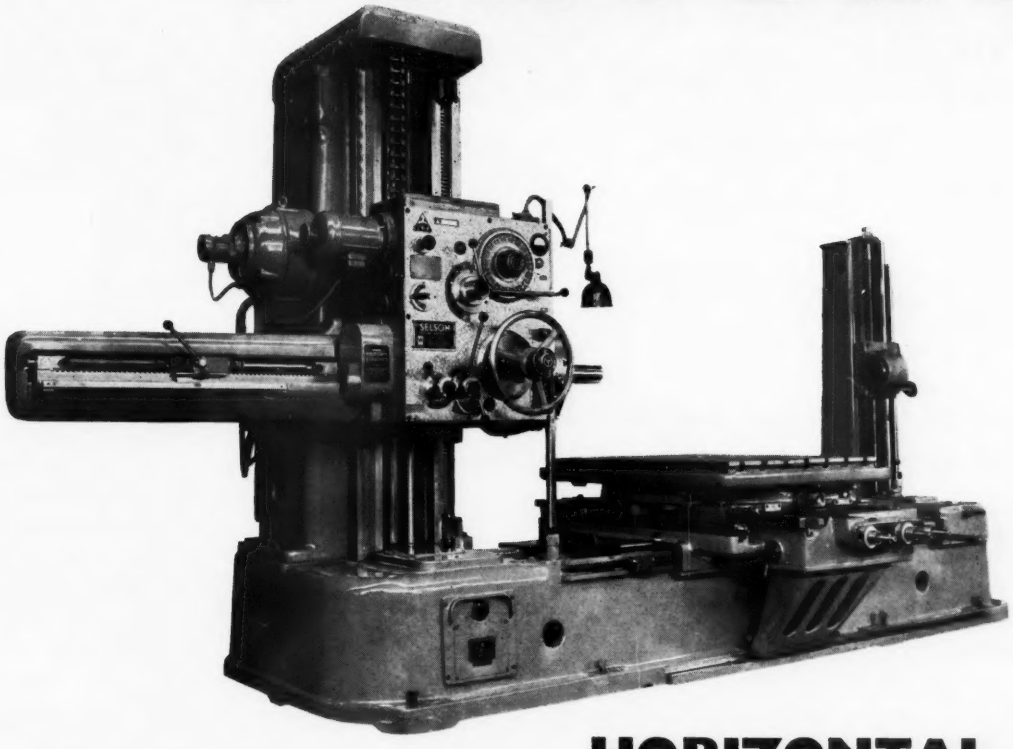
*Sintox Technical Advisory Service*

This service is freely available without obligation to those requiring technical advice on the application of Sintox Industrial Ceramics. Please write for booklet or any information required enclosing blue print if available.

**SINTOX**
INDUSTRIAL CERAMIC

*SINTOX IS MANUFACTURED BY* **LODGE PLUGS LTD., RUGBY**

# PLAUERT



## HORIZONTAL BORING AND FACING MACHINES

### *FOR EARLY DELIVERY*

- ★ Safety Clutch disengages automatically working feed or rapid traverse to prevent damage.
- ★ Power feed to table (Longitudinal, Cross and Circular).
- ★ Push buttons allow fine adjustment of Spindle or Faceplate when setting.
- ★ Automatic cross feed to facing head.
- ★ Designed and built for Precision Boring, Drilling, Milling, Threading, Reaming and Facing.
- ★ Enduring Accuracy
- ★ High Productivity ability.
- ★ Wide speed and feed range.
- ★ Ease of operation.

Models H80 and H100 are arranged with electric preselection of spindle speeds and feeds.

**BRIEF SPECIFICATION**

| | H63 | H80 | H100 |
|---|---|---|---|
| Diameter of Spindle | 2½″ | 3⅛″ | 3 1⅝″ |
| Max. diameter for facing | 22″ | 28″ | 35½″ |
| Working surface of table (Width × length) | 28″ × 35¼″ | 35½″ × 44¼″ | 44¼″ × 49¼″ |
| Number and range of spindle speeds | 16 | 18 | 27 |
| | 8-1400 r.p.m. | 5.6-1000 r.p.m. | 2.8-710 r.p.m |

**SOLE AGENTS**

Selson MACHINE TOOLS

## The Selson Machine Tool Co. Ltd

41-45 MINERVA ROAD, NORTH ACTON, LONDON, N.W.10

Telephone: Elgar 4000 (10 lines) Telegrams: Selsomachi, London, N W 10

THE 600 GROUP

# Barnaby

## metal cutting bandsaw

- CONTINUOUS CUTTING
- LONG BLADE LIFE
- HYDRAULIC FEED REGULATOR
- HYDRAULIC DOWN FEED
- AUTOMATIC KNOCK-OFF
- LESS MATERIAL WASTAGE

*There's a Material Saving — with the* **Barnaby** *bandsaw*

Developed for quicker and more efficient cutting-off of all types of material, steel, iron, brass, bronze, light alloys, etc. Capacity of 16″ x 6″ for rectangular sections or 10″ for round bars, fitted with hydraulic down feed enabling thin parallel cuts to be made in any material, leaving a smooth even face.

**CATMUR** MACHINE TOOL CORPORATION LIMITED

103 Lancaster Road, Ladbroke Grove, London, W.11. 'Phone PARk 9451/2

NRP 2071

JIGS AND FIXTURES

Plastic Moulds — Die-casting Tools — Press Tools — Special Tools

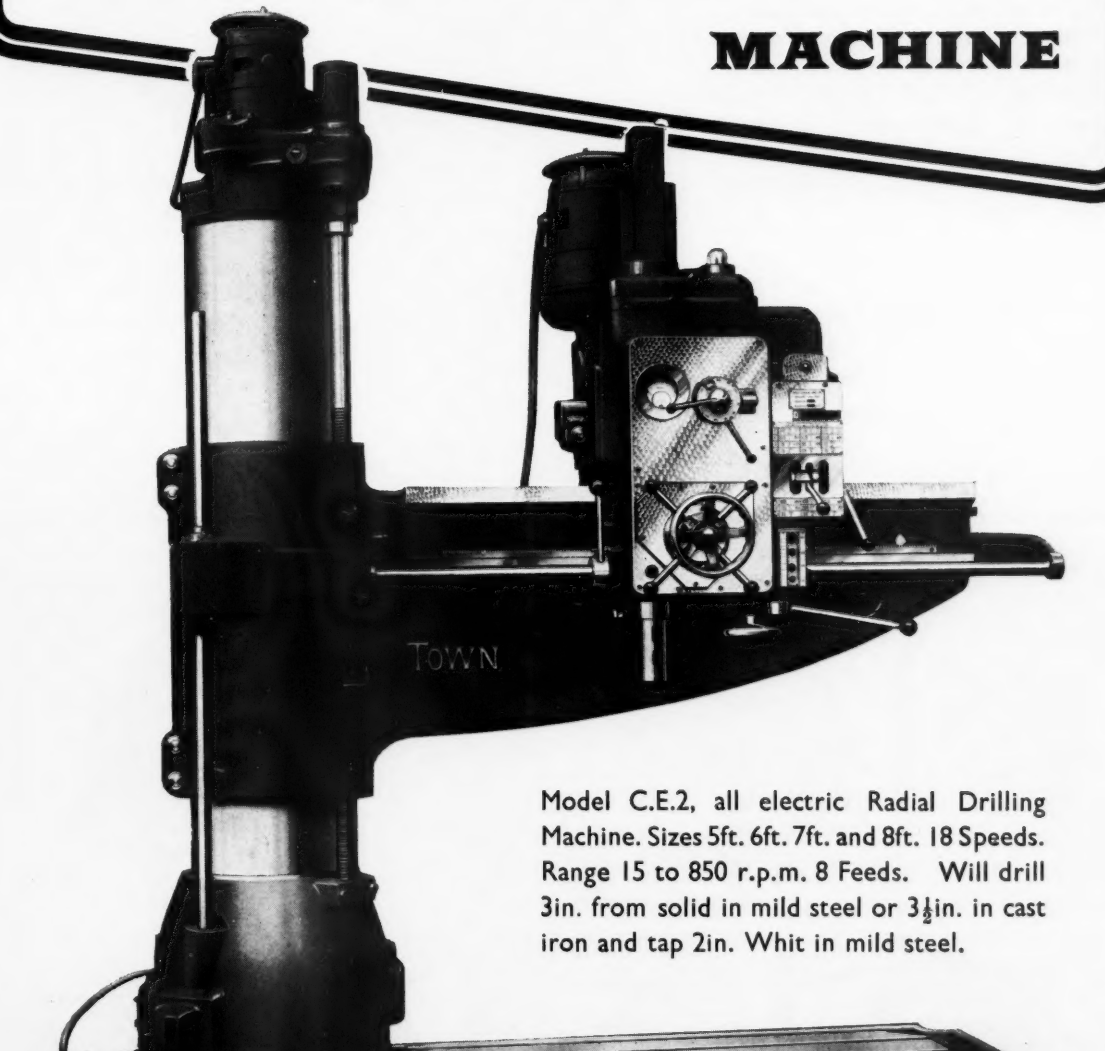
UNIVERSAL TOOLS LTD

*Tramway Path Mitcham Surrey*

*Telephone Mitcham 6111*

# THE NEW TOWN C.E.2.

## HEAVY RADIAL DRILLING MACHINE




Model C.E.2, all electric Radial Drilling Machine. Sizes 5ft. 6ft. 7ft. and 8ft. 18 Speeds. Range 15 to 850 r.p.m. 8 Feeds. Will drill 3in. from solid in mild steel or 3½in. in cast iron and tap 2in. Whit in mild steel.

**Makers of high class Drilling Machines for 55 years**

## Fred.K Town & Sons Ltd

HALIFAX • YORKS • ENGLAND

Write for leaflets on the complete TOWN range of machines T14 Y

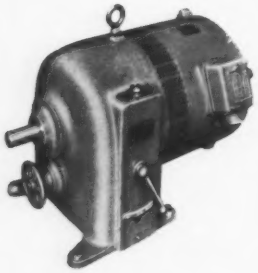
# Unique

"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

C. P. Newall & Co., Ltd.

POSSILPARK GLASGOW · N

**MULTIPLE SPEED GEARBOXES** with co-axial shafts, capacities 5, 15, 35 H.P. overall ratios from 1-1 up to 7-1. Two, three or four speeds. Motorised or non-motorised.



**"STRATELINE" SPEED-REDUCER** Horizontal foot-mounted, universal flange - mounted. Single, double or triple stage. Motorised or non-motorised Co-axial shafts. Ratios up to 10,000 to 1. Output TORQUE up to 64,000 lb. in.

**VARATIO POSITIVE VARIABLE SPEED GEARS.** for speed changing under power. Capacities up to 45 H.P. Overall ratios, standard 2-1, 3-1, 4-1, in 7, 9, 13 speeds respectively. Spur gear, co-axial drives.

**VALVE AND WINCH OPERATING GEAR.** Co - axial shafts. Flange - mounting. Developed for individual applications. Hand or power operation.

**above** are typical examples from our range of variable speed gear units and speed reducers. Special units developed to customers' requirements.

*Write for further details.*

VARATIO-STRATELINE GEARS LTD

277-279 Aberdeen Ave., Trading Estate, Slough, Bucks.
Telephone : Slough 20271/2. Telegrams : Varatio, Slough.

# BALDWIN FLUID POWER

Right from the drawing board stage BALDWIN pneumatic and hydraulic equipment keeps one aim in view—RELIABILITY!
Top-quality design features not found in competitive equipment include—

* Polished, hard-chrome plated cylinder bores and piston rods.
* Self adjusting oil and water resistant seals.
* Rugged, malleable cast-iron and steel construction completely rust and corrosion proof inside and out.
* Built-in cushioning to absorb the shock of heavy loads moving at high speeds.

Remember! Only BALDWIN can offer 432 standard types of cylinder with 6 bore sizes and 8 standard mountings for Air 150 p.s.i. and Oil 250 p.s.i. maximum operating pressures!

**PNEUMATIC AND HYDRAULIC CYLINDERS AND VALVES**

for quality, efficiency and reliability

**Consult Baldwin—technical advice is readily available—without obligation!**

WRITE NOW for a copy of this new Fluid Power Catalogue No. B6/503. It gives complete information on the entire range of Baldwin Fluid Power Equipment.

**BALDWIN INSTRUMENT COMPANY LIMITED**

**Dartford · Kent · Dartford 2948** One of the Harper Group of Companies

B61

# Mild steel fabrication problems ?

M126

*Typical run of ducting supplied to a large glass manufacturing concern. Ducting fabricated throughout from ¼" mild steel plate, and ranging from 4'-0" to 6'-0" diameter.*

Whether your plant requires fabrications of simple or complicated manufacture we can be of service to you. Fabrications of bolted, welded or rivetted construction made to individual specifications in almost any thickness of mild steel plate.

★ *Work performed to Lloyd's class 2 specification*

**Markland Scowcroft have the answers!**

**MARKLAND SCOWCROFT LIMITED** Bromley Cross, Nr. Bolton *Telephone EAGLEY 600 (5 lines)*

---

# SLIDEWAY GRINDING

**SPECIALISTS IN MACHINE TOOL REBUILDING**

HEADS FOR HORIZONTAL AND VERTICAL GRINDING WITH THE BROCKHOUSE UNIT GRINDING HEAD AND TRUING DEVICE.

★ Easily adaptable on most standard machines.
★ Rapid and accurate.
★ Slideway Grinding Enquiries invited.

Write for descriptive folder to :

**J. BROCKHOUSE & CO. LIMITED**

**Machine Tool Division**

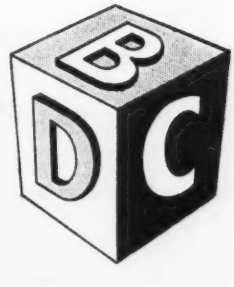
**ELMS WORKS : PENN ROAD : WOLVERHAMPTON**

Phone: Wolverhampton 23801

**AT SETTING**

# why pick on us?

Yes, why? asks the motorist, faced with yet another demand on his purse — parking meters. Well, it's a good question, and maybe the Minister of Transport knows the answer. But if you've got to pay, you've got to pay — and here's a meter that'll make it almost a pleasure (road funds to you, too!). It's the Duncan Miller Model 60, now being made in this country by Adams Powel Equipment Ltd. *They* picked on us to cast the parts — 90% of them in zinc. The largest weighs 5¾ lbs., the smallest 0.013 lbs. Have *you* got a pressure die casting problem? Come and park it on us.




## the whole in one

CERTIFIED ZINC ALLOY ZAMCA DIE CASTERS

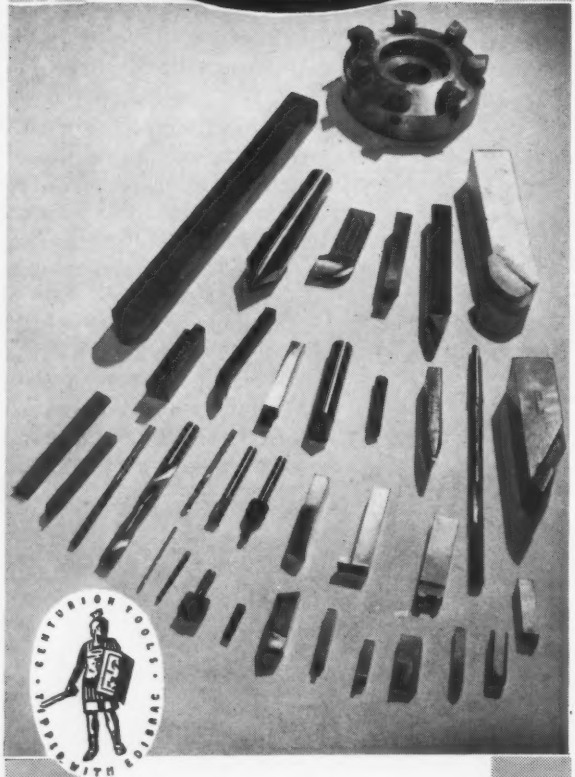
**BRITISH DIE CASTING AND ENGINEERING COMPANY LIMITED**

EDWARD ROAD · NEW BARNET · HERTS · TEL · BARNET 9211

Also at WEST CHIRTON TRADING ESTATE · NORTH SHIELDS · NORTHUMBERLAND
NORTH SHIELDS 2100

CRC 33

Think hard-think EDIBRAC



For further details
write for complete catalogue

EDIBRAC LIMITED

Manufacturers of

Tungsten Carbide Tipped Tools and Cutters

Made entirely at

CENTURION WORKS BROADHEATH NR. MANCHESTER

dmEC2/1

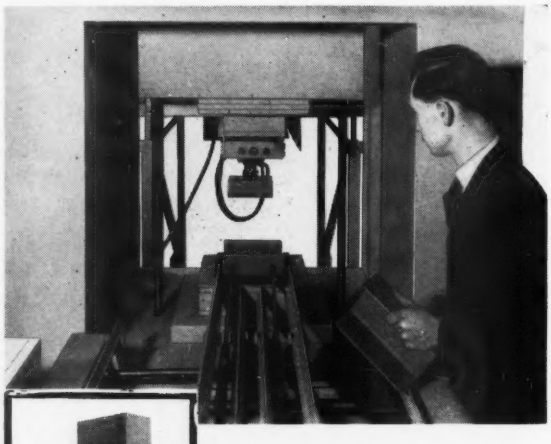
THE FIRM WITH HALF-A-DOZEN JIG BORERS for

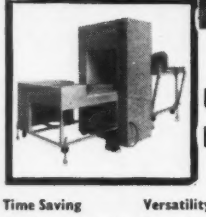
PRESS TOOLS

etc.

HIGH SPEED SERVICE TOOL CO. LTD.
Maple Road, Surbiton, Surrey. Elmbridge 1135-7

STUDER PROFILE GRINDING A SPECIALITY





UDAL Press Unloader and Loader give four-fold saving

**Time Saving**
The Loader permits continuous feeding with the minimum of Operator movement. The two units together on a Press running at 15 s.p.m. will give a production rate of 800 per hour with one Operator. With manual loading, two Operators would do well to reach 360 per hour.

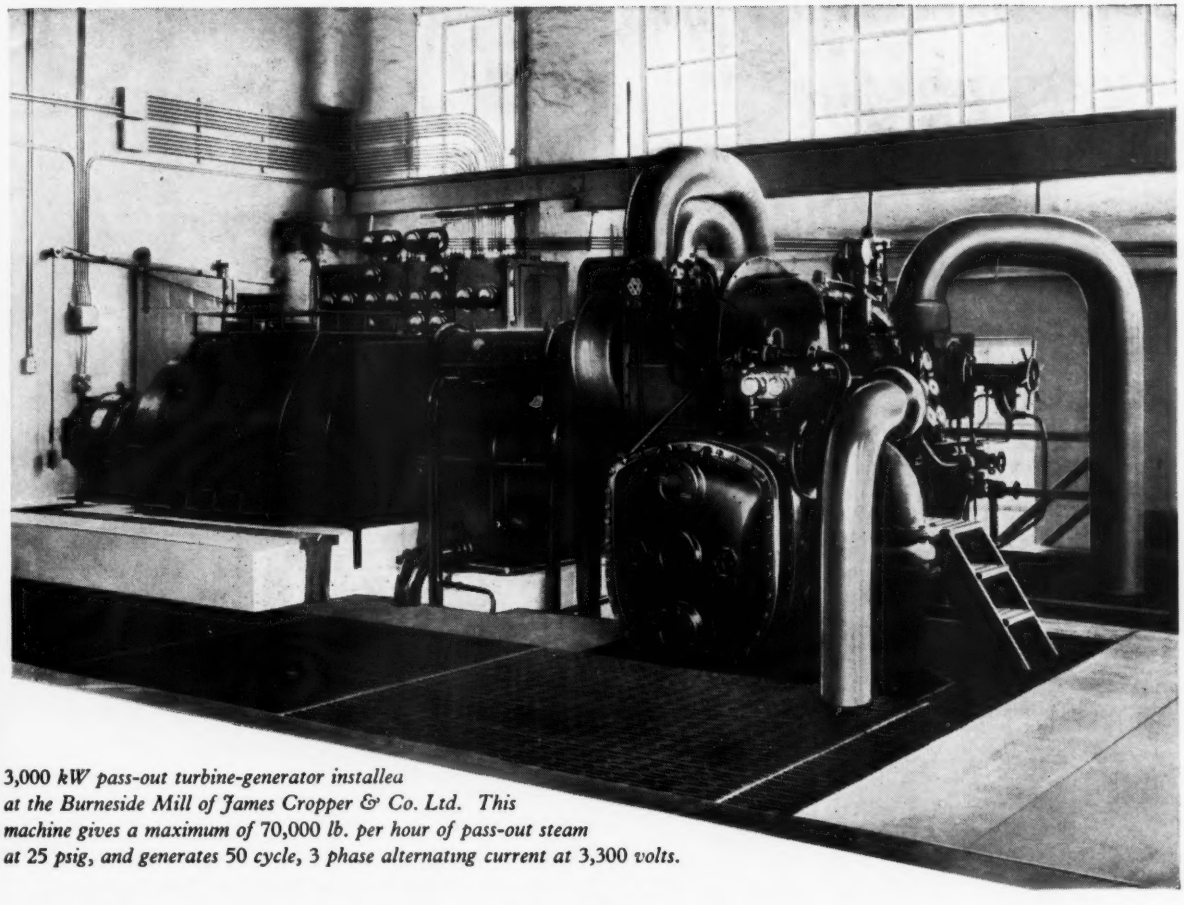
**Versatility**
Easy changeover from one job to another. Mounted on castor wheels with built-in height adjustment, the Units can be rolled clear for toolsetting or moved to another machine and reset within minutes.

**Economical Cost**
Relative to the savings in production costs from the use of these Units, their prices including installation, are attractive.

**Labour Saving**
The Unloader either replaces an Operator at back of Press or enables the front Operator to concentrate solely on feeding.

UDAL

J. P. UDAL LTD.,
Interlock Works,
Court Road,
Birmingham 12
Tel:. Calthorpe 3114



*3,000 kW pass-out turbine-generator installed at the Burneside Mill of James Cropper & Co. Ltd. This machine gives a maximum of 70,000 lb. per hour of pass-out steam at 25 psig, and generates 50 cycle, 3 phase alternating current at 3,300 volts.*

# Steam is costly

## -make it work

In many industries where steam is used for processes or heating it is economical to install Metropolitan-Vickers pass-out turbine-generators and so generate electrical power and cut fuel costs.

Metropolitan-Vickers has had considerable experience in the design of self-contained pass-out and condensing steam turbines, and will be pleased to advise on their application in your particular industry.

**A·E·I TURBINE-GENERATOR DIVISION**

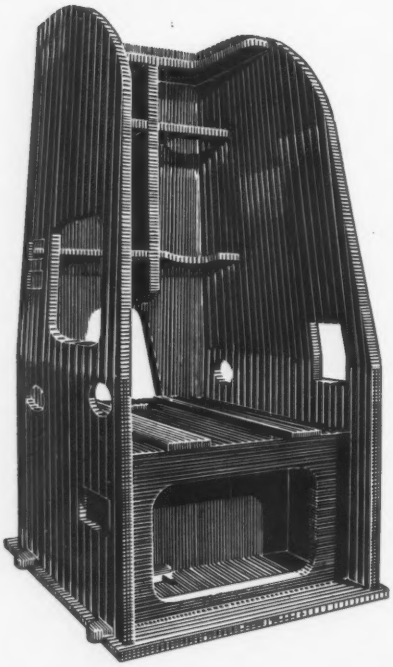
**MANCHESTER AND RUGBY**

A DIVISION OF ASSOCIATED ELECTRICAL INDUSTRIES LTD., incorporating the interests of M-V & BTH

WORKS AT MANCHESTER AND RUGBY, ENGLAND · GERMISTON, SCOTLAND · LARNE, NORTHERN IRELAND

B/B704

# *Your Specification... SHEEPBRIDGE Fabrication... Satisfaction!*



Fabrications of all types in medium and heavy steel plates . . . fabrications to your own drawings and specification. Whatever your needs you'll find that Sheepbridge can handle the job. Here are the full machine shop facilities you may need . . . Here are the latest skilled burning and welding techniques . . . And here are the efficient service and attention to detail that will ensure a good fabrication to your satisfaction. Next time, see Sheepbridge to make sure you get the best.

- **Machine tool frames**
- **Welded vessels**
- **Electric motor carcasses**
- **Repetition replacements for steel castings**

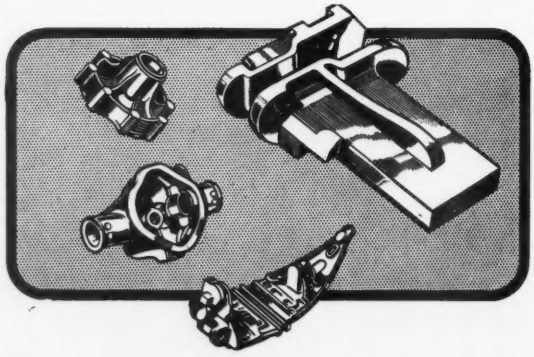
**Sheepbridge Equipment Limited • Chesterfield • England**
One of the Sheepbridge Engineering Group
**Telephone : Chesterfield 5471 Telegrams : Sheepbridge, Chesterfield**

# HEAT TREATMENT

- Capacity for case-hardening is now available in the most modern heat-treatment plant in London
- Gas or pack carburising with full metallurgical control over all operations
- Gleason quenching press equipment for pieces up to 36" dia. plus wide experience in the control of distortion
- Flame-hardening of gears up to 10 ft. dia. with latest electronically controlled equipment

**E.N.V. ENGINEERING COMPANY LIMITED**
HYTHE ROAD · WILLESDEN · N.W.10
Tel: LADbroke 3622-3-4-5-6

*AP 79*



*for DEPENDABILITY and MACHINABILITY*

# HALE MALLEABLE IRON CASTINGS

HALE & HALE (TIPTON) LIMITED DUDLEY PORT Staffs

PG LTD

*for* – **PRESS TOOLS:**

**PUNCHES & DIES,**
***optically ground***

**COMPLETE TOOLS.**
***–your design or our design***

***Burr-Free components and extreme accuracies through critical control of die-clearance and draft in segmental dies.***

**PRECISION GRINDING LTD.**

**MILL GREEN ROAD · MITCHAM · SURREY · *Phone: MITCHAM 3014***

NRP.2024

**SIR ERIC BOWATER—Chairman and Chief Executive of the Bowater Paper Corporation writes:—**

*"We have always been highly conscious of the need for fuel economy in our mills and factories. We welcomed the formation of the National Industrial Fuel Efficiency Service, and from the beginning have co-operated with them to the fullest extent, using their experience and staff to supplement that of our own engineers. We are glad to acknowledge the increased efficiency resulting from this co-operation.*

*We believe that, where no trained combustion staff is available, this Service is almost indispensable."*

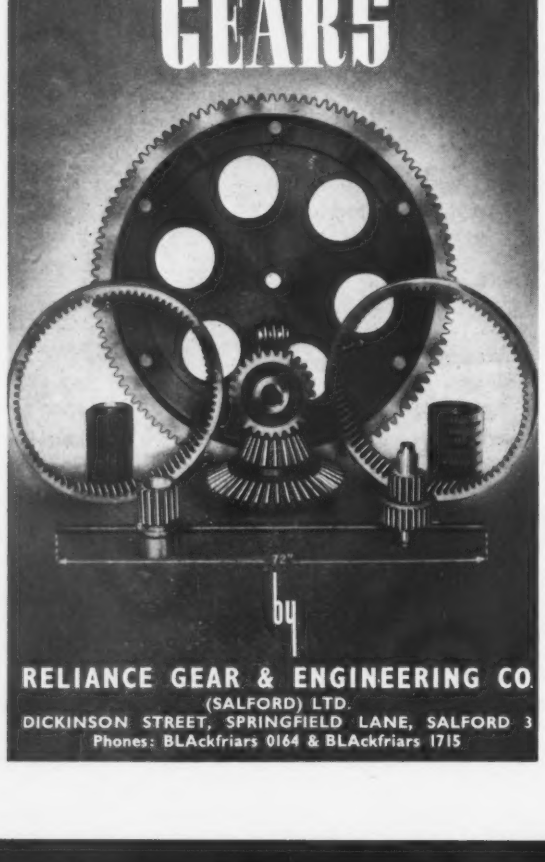
Eric V. Bowater

Call in N·I·F·E·S—Industry's own non-profit-making Service for advice on the efficient use of all fuels, heat and power.

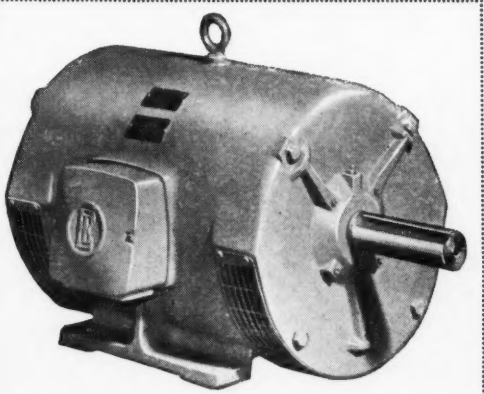
*For address of nearest Area Engineer write to:—*

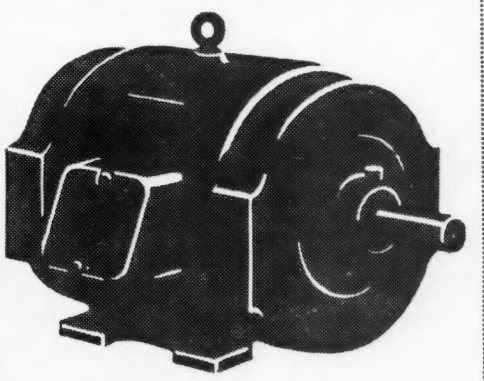
**N·I·F·E·S** *National Industrial Fuel Efficiency Service*

*Head Office:* **71 GROSVENOR STREET LONDON W1** · *Telephone:* Hyde Park 9706



# same size – same weight





## ...but **this motor** gives ***far more power***

The new 'ENGLISH ELECTRIC' standardised ventilated motors using class 'E' insulation and built to the latest B.S. specification 2960/1958 give far more power for the same frame size. For a given horsepower the motor required is smaller and lighter and costs less.

These new motors—from ½ h.p. to 50 h.p. in six frame sizes—have endshields and terminal boxes which turn to any of four 90° positions for floor, wall, or ceiling mounting. Publication DM/239 giving details of the range will be sent on request.

*Most sizes AVAILABLE FROM STOCK*

STANDARDISED AND INTERCHANGEABLE

# 'ENGLISH ELECTRIC'

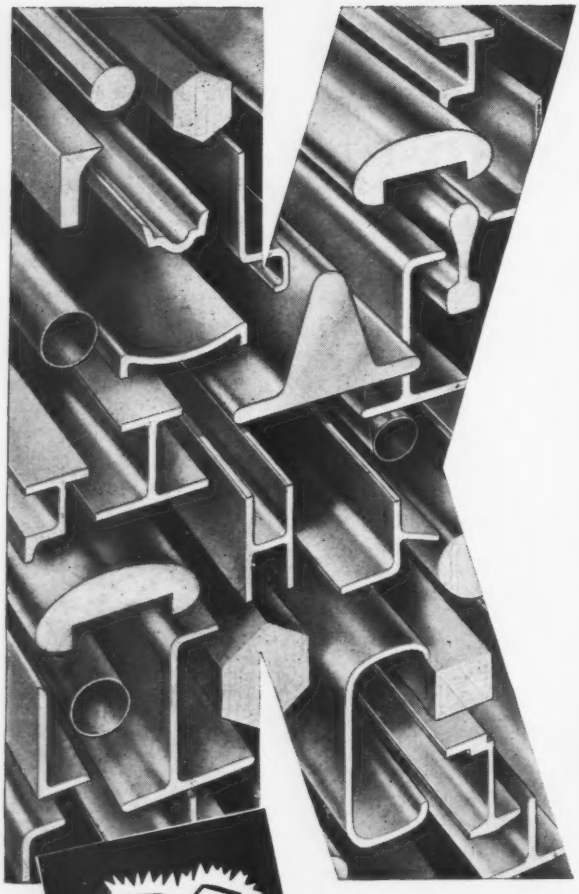
## B.S.D. ventilated motors

THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2

*Industrial Motor Works, Bradford*

WORKS: STAFFORD · PRESTON RUGBY · BRADFORD · LIVERPOOL ACCRINGTON

DM. 67AK7



K for ALUMINIUM ALLOYS

First-quality Aluminium Alloys, for innumerable applications — this is what "K" has come to mean to an ever-growing number of firms, including some of the foremost names in industry. It also means copper and aluminium wire strip and strand, for electrical and other purposes.

**RODS · TUBES · BARS · SECTIONS · WIRE**

Durcilium (Regd.) Alumagnese

**E. & E. KAYE LTD.**

PONDERS END · ENFIELD · MIDDLESEX

*Telephone.. Howard 1601* *Telegrams.. Cuwire, Enfield*

K 2 TA. 5121

MAN POWER IS TIME POWER

Time on the job enters into every stage of industrial production. Arrivals and departures, time on the bench or machine, breaks for meals and overtime are all related to cost of production.

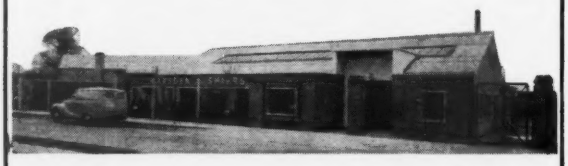
GLEDHILL-BROOK Time Recorders provide the most adaptable means of recording regular or irregular hours on the job, automatically and accurately, every minute of every hour, day, and night.

With 8-day mechanical clock movement or electrical operation.

**Write for full information and illustrated leaflet to:—**

GLEDHILL —BROOK

**GLEDHILL-BROOK TIME RECORDERS LTD.**
**20 EMPIRE WORKS HUDDERSFIELD**



**LET US BE YOUR MACHINE SHOP**

**WE INVITE YOUR ENQUIRIES FOR:**

Capstan, turret and centre lathe work: Milling—all types—internal, surface and universal grinding. GSIP jig-boring, drilling, shaping, thread-milling, honing, etc. also for tool work. Ours is a complete machine shop to meet your every need.

A.I.D. and A.R.B. Approved.

**MARSDEN & SHIERS LTD.**

**DAVIS ROAD · CHESSINGTON · SURREY**

**Phone ELMBRIDGE 5333-4**

# *In search of THE RIGHT SOLUTION*

*FOR the efficient cleaning and degreasing of every known metal and alloy there is an "S.A.C." specific. For treatment in circumstances complicated by unusual conditions—the answer can be found by the "S.A.C." technicians. Consultation with "S.A.C." is the shortest, most economical way of finding the right solution for your metal cleaning problems. We have the equipment of today—the experience of many years.*

PRODUCTION PROVED PRODUCTS

## SUNBEAM ANTI-CORROSIVES LTD.

*CENTRAL WORKS · CENTRAL AVENUE · WEST MOLESEY · SURREY*

*Telephone: Molesey 4484 (5 lines)* *Telegrams: Sunanticor, East Molesey*

*Manufacturers of*

STRIPALENE · FERROCLENE · ALOCLENE · FERROMEDE · BRAZOCLENE

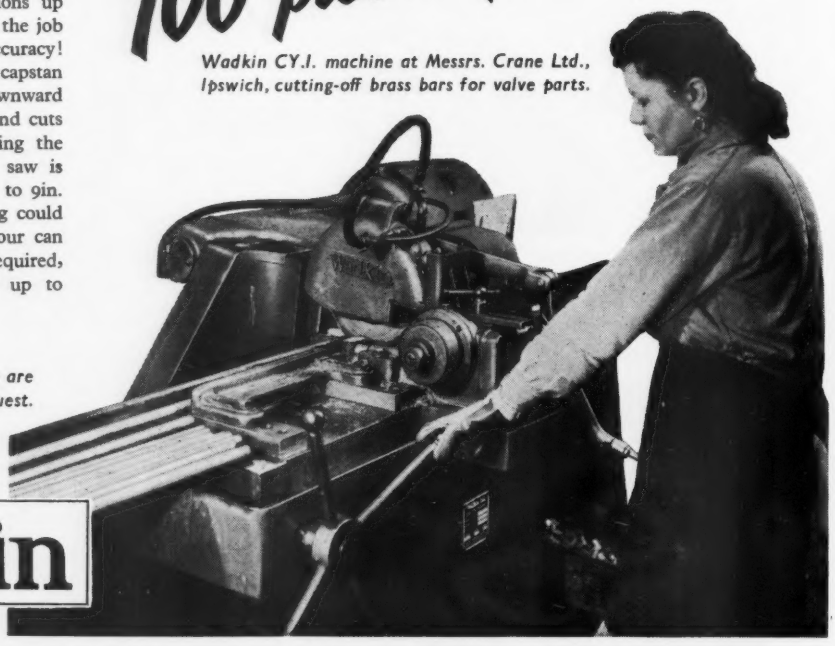
*(Regd. Trade Marks)*

APPROVED BY ADMIRALTY, WAR OFFICE AND AIR MINISTRY

# Cutting-off brass bar at *700 pieces per hour!*

The Wadkin C.Y. is the ideal machine for cutting-off non-ferrous bars or extrusions up to 4in. by 2½in. or 3in. round. It does the job with ease, speed, and consistent accuracy! The material is moved into position by capstan wheel operated feed and a short, easy downward movement of the handle both clamps and cuts through the material. Even after cutting the material is still held firmly until the saw is raised clear and allows components up to 9in. long to fall through the chute. Nothing could be simpler in operation! Unskilled labour can easily maintain high rates of output. If required, machine can be arranged to cut-off up to 3ft. 6in. long.

*Full details of the Wadkin C.Y. machine are given in Leaflet 597, available on request.*



*Wadkin CY.I. machine at Messrs. Crane Ltd., Ipswich, cutting-off brass bars for valve parts.*

**Wadkin**

Wadkin Ltd., Green Lane Works, Leicester. Tel: 68151 (7 lines) London Office: 62-64 Brook Street, W.1. Tel: MAYfair 7048

600 lb. 1 TON 3 TON

**HOLT**

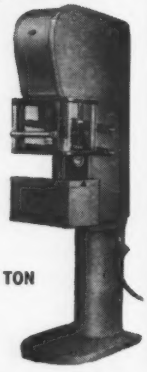
**PNEUMATIC PRESSES**

★ *For*

**BLANKING, PIERCING, BROACHING, FORMING, ETC.**

*OR WHEN USED WITH A VIBRATOR FOR—*

**RIVETING AND PEENING.**



5 TON

**HOLTITE CLAMPS**

These versatile Toggle Clamps are available in various sizes. For powerful grip, accurate and speedy location of work, they have no equal.

*Write NOW for full details and leaflets*

**JAMES HOLT ENGS. LTD.**

**MILTON WORKS, MULE ST., BOLTON, LANCS, ENG.**

*Phone: BOLTON 1209*

## Radio-Frequency—too!!

Over the years more and more companies have entrusted us with their components for FLAME HARDENING and learned its amazing possibilities.

Meantime we have developed a RADIO-FREQUENCY Department and can offer service from Valve Generators up to 125 Kva.

On Starter Rings we have full automation. Yet we know there is still much to learn . . . remarkable possibilities!!

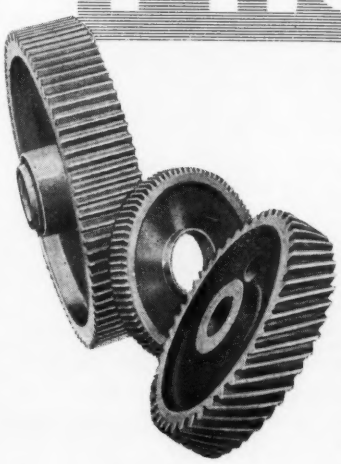
**FLAME HARDENERS LIMITED**

Shorter Works · Bailey Lane · Sheffield I

**Telephone 21627**

**DAVID BROWN**

# PH30



## PRODUCTION GEAR HOBBING MACHINE

**Largest in our range of automatic hobbing machines, the PH30 is characterised by its massive construction, thus eliminating any possibility of vibration at the highest production rates. Of the moving table type, it is designed to meet modern high speed production techniques for a wide variety of spur and helical gears up to 30 inches diameter.**

**Cutting cycle fully automatic, easily set, controlled by single push button. Hydraulic clamping eliminating manual operation. All controls carefully located for quick and simple operation.**

**Also supplied for manual operation. Optional universal hob slide permits the generation of worm wheels by the tangential feed method.**

**Full details are given in Publication M107.1**

THE
**DAVID BROWN**
CORPORATION (SALES) LIMITED
MACHINE TOOL DIVISION
BRITANNIA WORKS SHERBORNE STREET
MANCHESTER 3

# Cut SET UP COSTS!

ALL SIZES DELIVERED EX-STOCK

Change to

## ROCKWELL HELICAL CLAMPS

BRITISH PATENT

Why waste time building up rickety, makeshift clamps with anything that's handy? Get on the phone today and ask for full information about Rockwell Helical Clamps. These ingenious clamps have been designed for simple quick and positive mounting, with negligible clamp projection over work piece. Each clamp is a complete unit, with no parts to lose.

• WRITE OR PHONE FOR LEAFLET GIVING PRICES SIZES AND FULL TECHNICAL DETAILS

-TODAY!

WELSH HARP, EDGWARE ROAD, LONDON, N.W.2. GLAdstone 0033

ROCKWELL MACHINE TOOL CO. LTD.

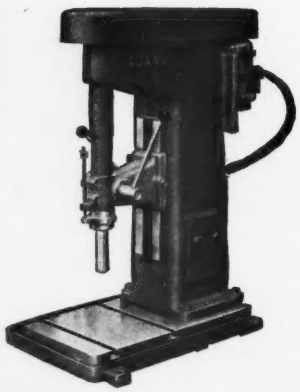
Also at
Birmingham—Springfield 1134/5. Stockport—Stockport 5241. Glasgow—Merrylee 2822

# AJAX HEAVY DUTY DRILLING MACHINES

These *robust* machines are designed for day-in day-out large scale production drilling. Exceptionally slow speeds can be provided by special vee-pulleys and low speed motor for reaming and tapping.

The spindles are accurately ground to fine limits and the rack teeth are cut into the spindle sleeve.

Available as bench or pedestal models.



| | |
|---|---|
| A J 1. | ¾" dia. in steel or cast iron. 1" dia. in softer metals. |
| A J 2. | ¼" dia. |
| A J 3. | ⅝" dia. (steel or cast iron). |
| A J 4. | 4' 6", 5' 0" and 5' 6" radius. |

*Full details from:*

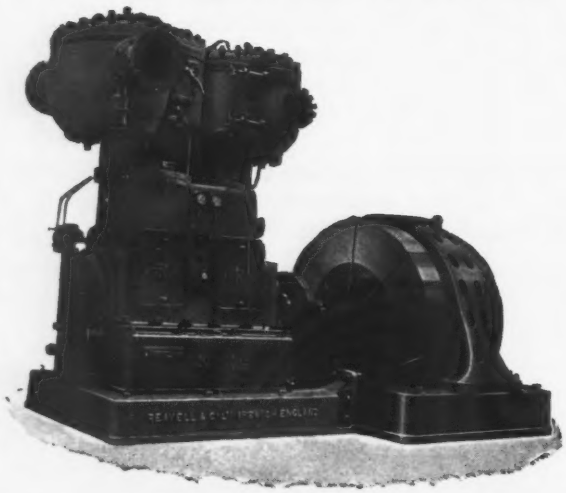
AJAX

AJAX MACHINE TOOL CO. LTD.
WEST MOUNT WORKS · HALIFAX · YORKSHIRE
Prop. ADA (HALIFAX) LTD.

WHEN YOU ARE WANTING NEW

# AIR COMPRESSORS

DO NOT FORGET THAT WE HAVE
A COMPLETE RANGE TO SUIT ALL DUTIES



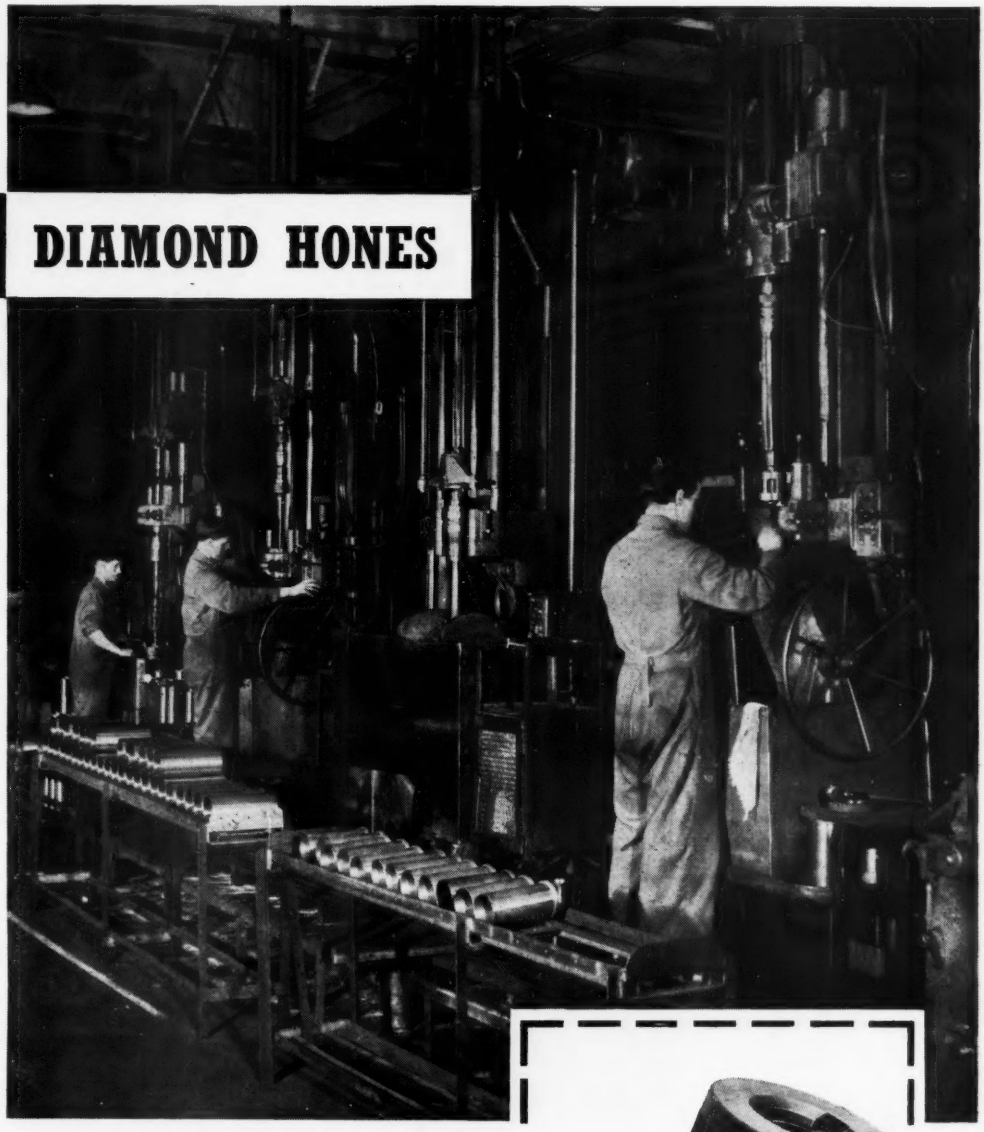
Whatever it is you need—large or small capacity—high or low pressure—we can supply the best machine for the purpose, and our fifty years of specialised experience are at your service.

## REAVELL & CO. LTD.

IPSWICH

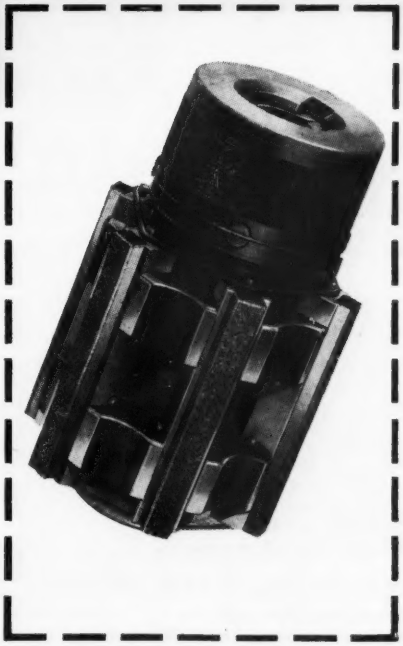
Telegrams: Reavell, Ipswich Telephone Nos.: 2124-5

# NEVEN DIAMOND HONES



*Photograph by kind permission of Leyland Motors Ltd.*

**Neven hones are used by the leading engineering firms. The illustration shows our hones in use at Leyland Motors Ltd.**



**IDP**

**IMPREGNATED DIAMOND PRODUCTS LIMITED OF GLOUCESTER**

TELEPHONE 21164 (3 LINES)
TELEGRAMS IMPREG GLOUCESTER

*Neven Diamond Tools Cut, Drill and Grind the Hardest Materials*

# BAKER

## The BAKER-PERA
# TOOL RADIUS
## Grinding Attachment

This attachment to your tool and cutter grinder, designed by P.E.R.A.*, enables the cutting and clearance angles of single-point cutting tools to be ground accurately to pre-determined angles, and the nose radius to be accurately ground to blend with the edges.

**Well ground tools last longer, give better finish and save time on costly machine tools.**

* Production Engineering Research Association of Great Britain

*Write for descriptive leaflets to:*

**C. BAKER of Holborn LTD.**

METRON WORKS PURLEY WAY CROYDON SURREY
CROydon 3845-6-7-8

---

**FROM**
**1/250th H.P.**
**to**
**1/3rd H.P.**

Illustrated:
Type 334C40 Geared Motor, with A.C. and D.C. interchangeable frames 1-20 r.p.m. Torque: 20.10 lbs/ins.

*There's a* **FRACMO** *for your job!*

*The wide range includes:*

UNIVERSAL 1/250 to ¼ h.p.
SINGLE, SPLIT PHASE 1/100 to ¼ h.p. and
CAPACITOR 1/80 to 1/6 h.p.
3-PHASE 1/20 to 1/3 h.p.
SYNCHRONOUS 1/100 to 1/16 h.p.
SHADED POLE 1/160 h.p. at 1,300 r.p.m.
GEARED UNITS 0.125 to 600 r.p.m.
Torque up to 850 lbs/ins.

★ ***Make use of our vast resources and many years of experience.***

**FRACTIONAL H.P. MOTORS LTD**
**Rookery Way, Hendon, N.W.9. Phone: Colindale 8022/4**
**Also at Birmingham**

DaF11581P

---

**CITY OF LEICESTER**
**EDUCATION COMMITTEE**
**College of Technology and Commerce**

## School of Commerce

**WORK STUDY RESIDENTIAL COURSES 1958/59**

**TEN-WEEK WORK STUDY TRAINING COURSE.** The College is one of the establishments originally selected for the national scheme for training Work Study practitioners. Courses commencing next January, April.

**WORK STUDY APPRECIATION COURSE (ONE-WEEK):** on the objectives, potentialities and problems of Work Study in relation to the aims and activities of the whole organisation. For departmental managers, personnel officers, supervisors, etc. Courses in February, May.

**WORK STUDY ADVANCED TECHNIQUES COURSE (ONE-WEEK):** on such topics as Ergonomics, Work Sampling, P.M.T.S., Operational Research, Organisation and Method, etc. Courses in November, March, June.

**Also:** short residential courses in GENERAL FOREMANSHIP (three weeks); MIDDLE MANAGEMENT (one week); and a 'SANDWICH' COURSE IN MANAGEMENT STUDIES for management trainees and others with management potential.

*Further details from*

**The Head of the School of Commerce,**
**College of Technology and Commerce, Leicester.**

*Something New!*

# CEJ "HI-TEN" TAPS

***HAVE YOU ANY REALLY TOUGH TAPPING PROBLEMS IN HIGH TENSILE STEELS?***

A NEW MANUFACTURING PROCESS IS GIVING AMAZING RESULTS AND MUCH LONGER TAP LIFE ON THESE DIFFICULT MATERIALS

✻ ***Tell CEJ about your problems and they will find the answer***

**C.E. JOHANSSON LTD.**

SOUTHFIELDS ROAD DUNSTABLE · BEDS

DHB/7097

## *INDEX TO ADVERTISEMENTS*

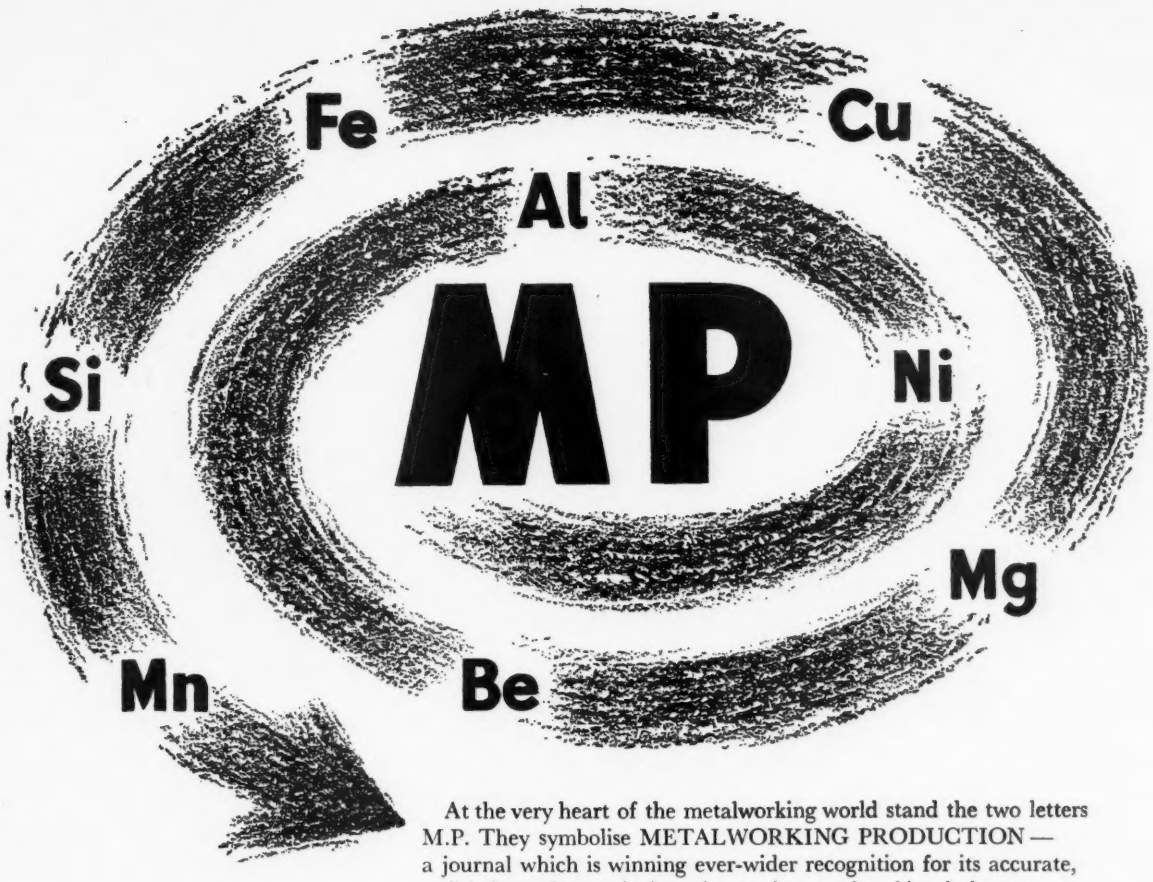
Please note that all advertisement pages are prefixed with the letter "A".


| | Page |
|---|---|
| Adcock & Shipley, Ltd. | A16 |
| Ajax Machine Tool Co. Ltd. | A92 |
| Allen, Edgar, & Co. Ltd. | A48 |
| Allspeeds, Ltd. | A13 |
| Aluminium Wire & Cable Co. Ltd. | A70 |
| Archimedes-Diehl Machine Co. Ltd. | — |
| Armstrong Patents Co. Ltd. | — |
| Arrow Electric Switches, Ltd. | A64 |
| Asquith, William, Ltd. | A45 |
| Associated Electrical Industries, Ltd. | A83 |
| Avery, W. & T., Ltd. | — |
| B.S.A. Tools, Ltd. | A65 |
| Baird & Tatlock (London), Ltd. | A29 |
| Baker, C., of Holborn, Ltd. | A94 |
| Baldwin Instrument Co. Ltd. | A79 |
| Barber & Colman, Ltd. | — |
| Barraclough, R. W., Ltd. | — |
| Baume & Co. Ltd. | A60 |
| Benton & Stone, Ltd. | A37 |
| Birlec, Ltd. | — |
| Birmingham Aluminium Casting (1903) Co. Ltd. | — |
| Birmingham Tool & Gauge Co. Ltd. | A8 |
| Bolton Railway Wagon & Ironworks Co. Ltd. | A38 |
| Bratby & Hinchliffe, Ltd. | A66 |
| Bray Accessories, Ltd. | — |
| Bray, Geo., & Co. Ltd. | A15 |
| British Aero Components, Ltd. | — |
| British Die Casting & Engineering Co. Ltd. | A81 |
| British Tabulating Machine Co. Ltd. | A71 |
| British Thomson-Houston Co. Ltd. | — |
| British Timken, Ltd. | — |
| Brockhouse, J., & Co. Ltd. | A80 |
| Broom & Wade, Ltd. | A69 |
| Brown, David, Corpn. (Sales), Ltd., The | A74, A91 |
| Brown & Ward, Ltd. | — |
| Buck & Hickman, Ltd. | A59 |
| Burton Griffiths & Co. Ltd. | A65 |
| Butler Machine Tool Co. Ltd., The | — |
| Butterley Co. Ltd., The | — |
| Catmur Machine Tool Corpn., Ltd. | A76 |
| Centec Machine Tools, Ltd. | — |
| Churchill, Charles & Co. Ltd. | — |
| Churchill Machine Tool Co. Ltd. | — |
| Churchill-Redman, Ltd. | A26 |
| Ciba (A.R.L.), Ltd. | A17 |
| City of Leicester Education Committee | A94 |
| Cohen, Geo., Sons, & Co. Ltd. | — |
| Concentric Manufacturing Co. Ltd. | A52 |
| Cooper & Co. (B'ham), Ltd. | — |
| Coventry Climax Engines, Ltd. | *Outside Back Cover* |
| Coventry Gauge & Tool Co. Ltd. | A39 |
| Cow, P. B., & Co. Ltd. | A60 |
| Crawford Collets, Ltd. | — |
| Crofts (Engineers), Ltd. | A24, A25 |
| Crompton Parkinson (Stud Welding), Ltd. | — |
| Crosland, William, Ltd. | — |
| Dawe Instruments, Ltd. | A56 |
| Dawson Bros., Ltd. | — |
| Dean Smith & Grace, Ltd. | A4 |
| Dowding & Doll, Ltd. | A11 |
| Drummond Asquith (Sales), Ltd. | A44 |
| Drummond Bros., Ltd. | — |
| E.N.V. Enginering Co. Ltd. | A49, A84 |
| Edibrac, Ltd. | A82 |
| Edwards, F. J., Ltd. | A62 |
| Electrical Development Association | A58 |
| Elgar Machine Tool Co. Ltd. | — |
| Elliott Bros. (London), Ltd. | — |
| Elliott, B. (Machinery), Ltd. | A70 |
| Engineering Materials and Design | A66 |
| English Electric Co. Ltd., The | A87 |
| English Steel Tool Corpn., Ltd. | — |
| Exors of James Mills, Ltd. | A21 |
| Fearns, Mear & Co. | — |
| Firth, Thos., & Brown, John, Ltd. | A73 |
| Flame Hardeners, Ltd. | A90 |
| Fletcher Miller, Ltd. | A32 |
| Ford Motor Co. Ltd. | — |
| Fractional H.P. Motors, Ltd. | A94 |
| G.P.A. Tools & Gauges, Ltd. | — |
| Gas Council, The | — |
| Gledhill-Brook Time Recorders, Ltd. | A88 |
| Glostics, Ltd. | A54 |
| Guest, Keen & Nettlefolds (Midlands), Ltd. | — |
| Hale & Hale (Tipton), Ltd. | A84 |
| Harris, John, Tools, Ltd. | — |
| Harrison, T. S. & Sons, Ltd. | — |
| Heenan & Froude, Ltd. | A53 |
| Herbert, Alfred, Ltd. | A55 |
| Heywood & Co. Ltd. | A66 |
| High Speed Service Tool Co. Ltd. | A82 |
| Hilger & Watts, Ltd. | — |
| Holman Bros., Ltd. | — |
| Holt, James (Engineers), Ltd. | A90 |
| Hordern, Mason & Edwards, Ltd. | — |
| Horstmann Gear Co. Ltd., The | — |
| Hymatic Engineering Co. Ltd., The | A30 |
| Ilford, Ltd. | A20 |
| Impregnated Diamond Products Ltd. | A93 |
| Ingham, Robert, Clark & Co. | A42 |
| Integra, Leeds, & Northrup, Ltd. | A67 |
| Jessop, Wm., & Sons, Ltd. | A3 |
| Johansson, C. E., Ltd. | A95 |
| Jones, E. H. (Machine Tools), Ltd. | A22 |
| Kaye, E. & E., Ltd. | A88 |
| Kearns, H. W., & Co. Ltd. | A34 |
| Keelavite Hydraulics, Ltd. | — |
| King, Geo. W., Ltd. | A27 |
| Kingsbury, Geo. & Co. (Machine Tools), Ltd. | — |
| Landis Lund, Ltd. | A18 |
| Lang, John. & Sons, Ltd. | — |
| Lang Pneumatic, Ltd. | A14 |
| Lapointe Machine Tool Co. Ltd. | — |
| Ley's Malleable Castings Co. Ltd. | — |
| Lincoln Electric Co. Ltd., The | — |
| Lloyd, F. H. & Co. Ltd. | A50 |
| Lloyd, Richard, Ltd. | A64 |
| Lodge Plugs, Ltd. | A74 |
| London Oil Refining Co. Ltd., The | — |
| Macready's Metal Co. Ltd. | A38 |
| Magnesium Elektron Co. Ltd. | A23 |
| Manganese Bronze & Brass Co. Ltd. | — |
| Markland Scowcroft, Ltd. | A80 |
| Marsden & Shiers, Ltd. | A88 |
| Martonair, Ltd. | — |
| Maxam Power, Ltd. | A35 |
| McGraw-Hill Publishing Co. Ltd. | *Inside Back Cover* |
| Metalworking Production | *Inside Back Cover* |
| Metropolitan-Vickers Electrical Co. Ltd. | A83 |
| Midgley & Sutcliffe, Ltd. | — |
| Minnesota Mining & Manufacturing Co. Ltd. | — |
| Mobil Oil Co. Ltd. | A41 |
| Monks & Crane, Ltd. | — |
| Morris, B. O., Ltd. | A5 |
| National Industrial Fuel Efficiency Service | A86 |
| Neill, James, & Co. (Sheffield), Ltd. | A36 |
| Newall, A. P., & Co. Ltd. | A78 |
| Newall Engineering Co. Ltd. | A57 |
| Newall Group Sales, Ltd. | A43 |
| New Conveyor Co. Ltd. | — |
| Northern Aluminium Co. Ltd. | A68 |
| Norton Grinding Wheel Co. Ltd. | A12 |
| Ofrex Group | A68 |
| Osborn, Samuel, & Co. Ltd. | — |
| Park Gate Iron & Steel Co. Ltd. | — |
| Parkinson, J., & Son (Shipley), Ltd. | A47 |
| Paterson Hughes Eng. Co. Ltd. | — |
| Pell, Oliver, Control, Ltd. | A33 |
| Philips Electric, Ltd. | — |
| Power Jacks, Ltd. | — |
| Precision Grinding, Ltd. | A85 |
| Pryor, Edward, & Son, Ltd. | A62 |
| Rack Engineering, Ltd. | A32 |
| Ratcliffe, F. S. (Rochdale), Ltd. | A86 |
| Rawlplug Co. Ltd., The | A31 |
| Reavell & Co. Ltd. | A92 |
| Reliance Gear & Eng. Co. (Salford), Ltd. | A86 |
| Rockwell Machine Tool Co. Ltd. | A19, A92 |
| Rocol, Ltd. | A63 |
| Rowland, F. E., & Co. Ltd. | A9 |
| Rubert & Co. Ltd. | — |
| Russell, S., & Sons, Ltd. | A72 |
| Ryder, Thos., & Son, Ltd. | — |
| Sandvik Swedish Steels, Ltd. | — |
| Saville, J. J., & Co. Ltd. | A3 |
| Selson Machine Tool Co. Ltd., The | A75 |
| Servis Recorders, Ltd. | — |
| Sheepbridge Equipment, Ltd. | A84 |
| Shell-Mex & B.P., Ltd. | — |
| Smart & Brown (Machine Tools), Ltd. | A10 |
| Smith, S., & Sons (England), Ltd. | — |
| Snow & Co. Ltd. | — |
| Société Genevoise, Ltd. | — |
| Sogenique (Service), Ltd. | A7 |
| Sparcatron | A6 |
| Spencer Gears, Ltd. | — |
| Spencer & Halstead, Ltd. | — |
| Square, D., Ltd. | — |
| Standard Piston Ring & Engineering Co. Ltd., The | A36 |
| Sternol, Ltd. | — |
| Streetly Manufacturing Co. Ltd. | A61 |
| Sunbeam Anti-Corrosives, Ltd. | A89 |
| Swift, Geo., & Sons, Ltd. | — |
| Sykes Machine Tool Co. Ltd., The | — |
| Sykes, W. E., Ltd. | — |
| Talbot Tool Co. Ltd., The | A1 |
| Taylor, Taylor & Hobson, Ltd. | — |
| Terry, Herbert, & Sons, Ltd. | — |
| Town, Frederick, & Sons, Ltd. | A77 |
| Udal, J. P., Ltd. | A82 |
| Unbrako Socket Screw Co. Ltd. | A2 |
| Universal Tools, Ltd. | A76 |
| Vacu-Blast, Ltd. | A72 |
| Van Moppes & Son (Diamond Tools), Ltd. | — |
| Varatio-Strateline Gears, Ltd. | A78 |
| Vaughan Associates, Ltd. | A51 |
| Wadkin, Ltd. | A90 |
| Wakefield-Dick Industrial Oils, Ltd. | — |
| Ward, H. W., & Co. Ltd. | A46 |
| Ward, Thos. W., Ltd. | — |
| Watches of Switzerland, Ltd. | A60 |
| Webster & Bennett, Ltd. | A28 |
| West, Allen, & Co. Ltd. | — |
| Welsh Metal Industries, Ltd. | — |
| Wickman, Ltd. | A40 |
| Wild-Barfield Electrical Furnaces, Ltd. | — |
| Woodhouse & Mitchell | — |


All communications regarding advertisements should be addressed to the Advertising Managers, T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2. Telephone: HOLborn 4743.
Printed by Maxwell, Love & Co. Ltd., 309 - 317 Borough High Street, London, S.E.1.

urnal

Page
A57
A43
—
A68
A12
A68
—
—
A47
—
A33
—
—
A85
A62
A32
A86
A31
A92
A86
19, A92
A63
A9
—
A72
—
—
A3
A75
—
A84
—
A10
—
—
—
A7
A6
—
—
—
A36
—
A61
A89
—
—
—
A1
—
—
A77
A82
A2
A76
A72
—
A78
A51
A90
—
A46
—
A60
A28
—
—
A40
—
—
—




At the very heart of the metalworking world stand the two letters M.P. They symbolise METALWORKING PRODUCTION — a journal which is winning ever-wider recognition for its accurate, well-informed, practical service to the metalworking industry.

*If your business* involves the fashioning of metals, you will find METALWORKING PRODUCTION an indispensable companion. Its down-to-earth and up-to-date editorial gives you all the latest information and developments in the vast metalworking industry. It has a practical approach to the solving of everyday problems and its clear layout makes for easy reading.

*If you buy*, METALWORKING PRODUCTION is your essential guide to the new techniques, the new processes, the new products and machines — in both its editorial and advertising pages.

*If you sell* to the engineering industry METALWORKING PRODUCTION is your essential advertising medium, reaching the managerial and production executives who between them control purchasing policy.

You have the additional advantage of using the only journal in the field with a paid circulation certified by the Audit Bureau of Circulations.

MEMBER OF THE AUDIT BUREAU OF CIRCULATIONS

# Metalworking Production

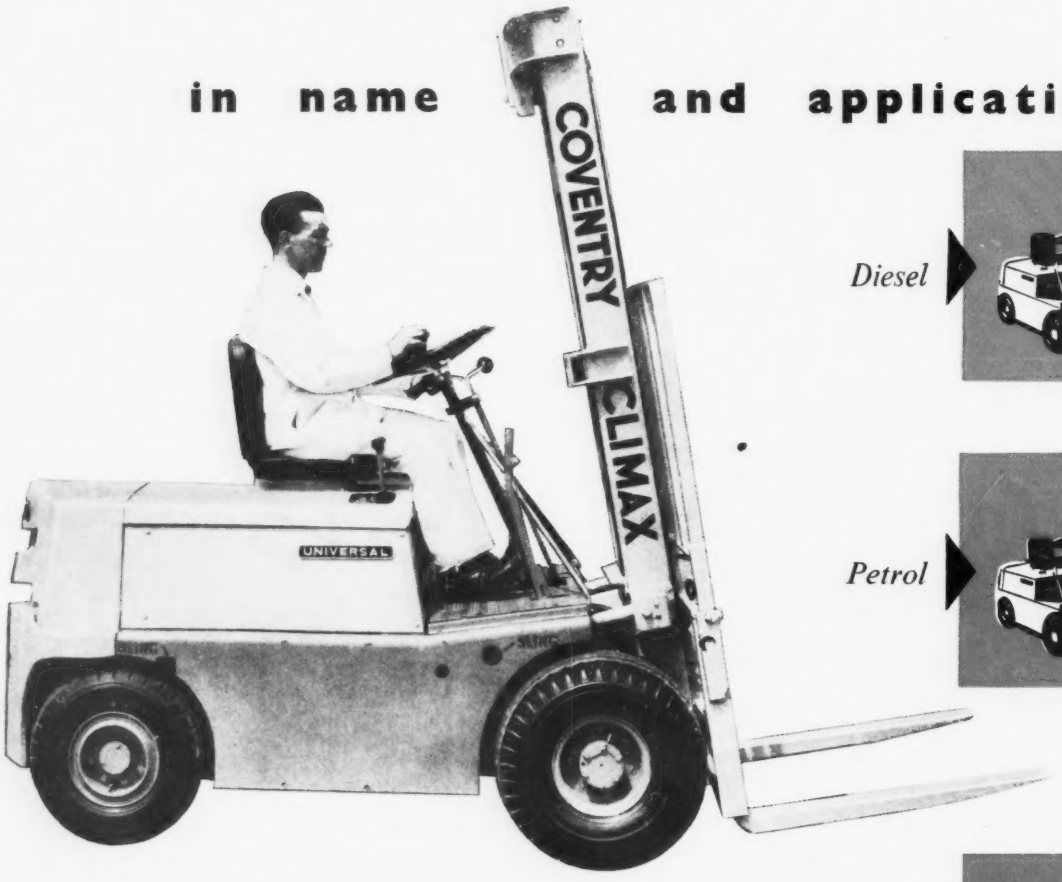
INCORPORATING THE MACHINIST

**Published weekly, 50/- per annum or 120/- for three years, post free from METALWORKING PRODUCTION, 95, Farringdon Street, London, E.C.4. CEN 0911.**

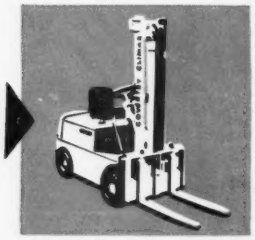
***Send today for a free copy of "Metalworking Production" and judge for yourself***

# UNIVERSAL

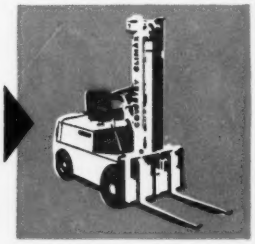
## in name and application



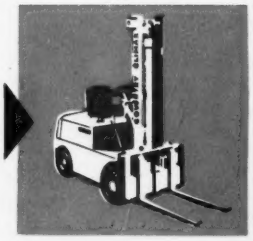

*Diesel*



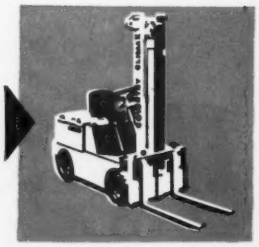
*Petrol*



*L.p.g.*



*Electric*



As the name suggests . . . in the new UNIVERSAL series we have produced a planned range of fork trucks which offers the user choice of any power source—diesel—petrol—l.p.g.—electric, within a universal basic design utilising the fullest possible standardisation of main components, such as masts, drive and steer axles, with resulting benefits in truck value, operating economy, and rationalised spares inventories.

**Coventry Climax**

COVENTRY CLIMAX
ENGINES LIMITED
Dept. P.E., COVENTRY

585

MAX
ITED
NTRY